FINAL DRAFT
BIOLOGICAL ASSESSMENT
ENDANGERED SPECIES ACT

BOGUE INLET CHANNEL RELOCATION PROJECT
EMERALD ISLE, NORTH CAROLINA

Prepared For:
Town of Emerald Isle, North Carolina

Submitted To:

U.S. Army Corps of Engineers
Wilmington, North Carolina

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Final Draft
Biological Assessment
Endangered Species Act

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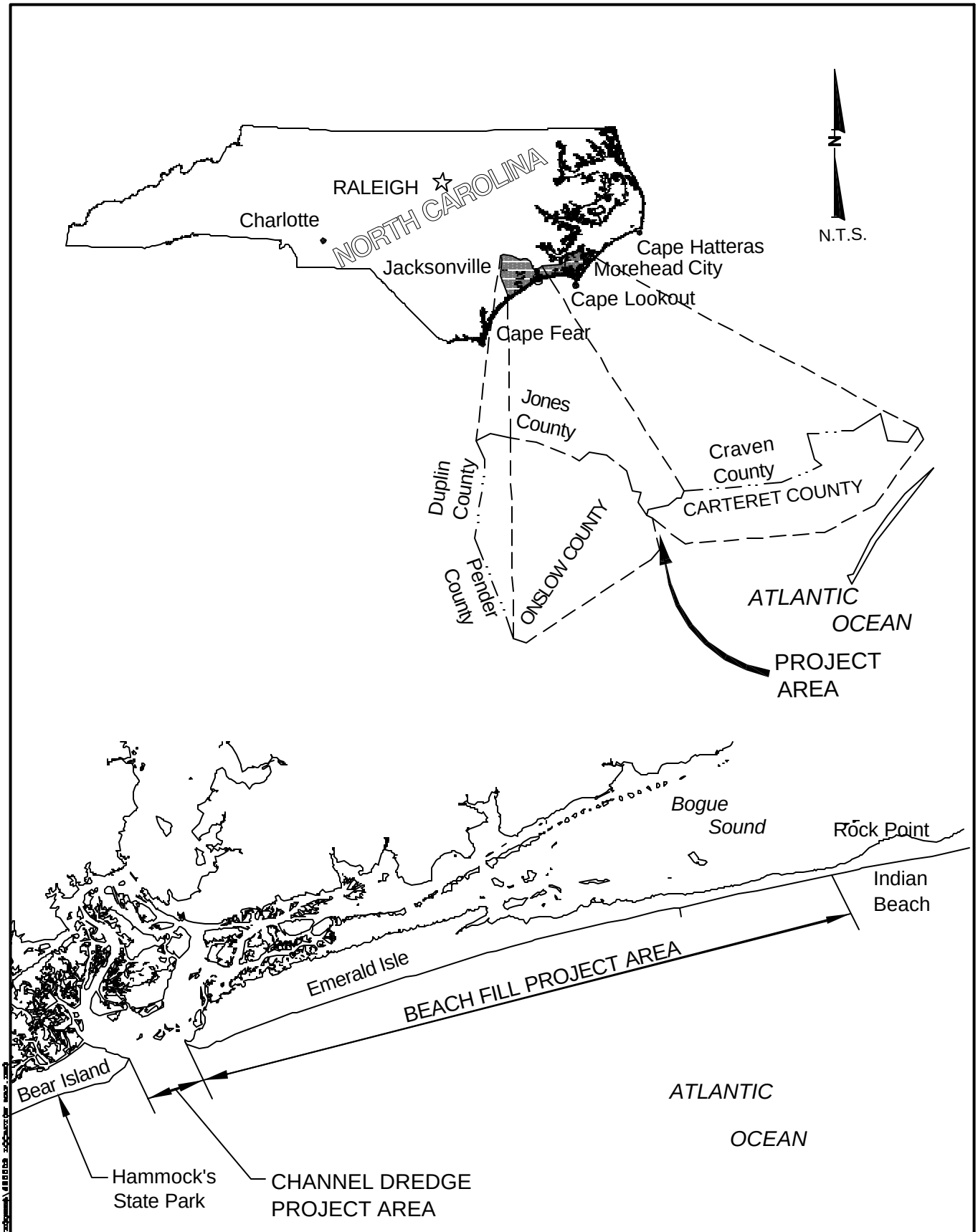
Bogue Inlet Channel Relocation Project
Emerald Isle, North Carolina

1. **PROJECT PURPOSE:** The Town of Emerald Isle, North Carolina, located along the western 11.2 miles of Bogue Banks (Figure 1.1) proposes to reposition the main ebb tide channel (or bar channel) through Bogue Inlet. This project is proposed to address a severe erosion problem that is threatening development and infrastructure located on the west end of the Town in an area known as The Pointe (Figure 1.2). The Bogue Inlet channel has been maintained by the U.S. Army Corps of Engineers (COE) for commercial and recreational boating interest since 1981. The COE is authorized to maintain the channel at a depth of 8 feet mean low water (mlw) over a width of 150 feet. In addition to the inlet channel, the Bogue Inlet Navigation Project includes a 6-foot mlw x 90-foot wide connecting channel between the Atlantic Intracoastal Waterway (AIWW) and the Bogue Inlet channel. The COE has maintained the inlet channel using shallow draft U.S. Government sidecast dredges, however, this maintenance activity is limited to the deepwater channel that exists at the time maintenance is performed. As a result, COE maintenance activities have been unable to stabilize the location of the channel. Any modification to the ebb tide delta channel location is subject to COE approval. In accordance with the National Environmental Policy Act (NEPA), an Environmental Impact Statement (EIS) will be prepared for the proposed Bogue Inlet Channel Relocation Project.

2. **PROJECT DESCRIPTION:** The Bogue Inlet Channel Relocation Project design proposes to relocate the channel approximately 3,550 feet west of the current location to a position that is consistent with the 1976 and 1978 ebb channel locations. Relocation of the inlet channel will result in the removal of 1,009,500 cubic yards of material from the design position and placed in two locations on Bogue Banks as described below. The proposed position of the new channel is shown on Figure 2.1. An analysis of historic photographs of the inlet system indicates that the west end of Emerald Isle (The Pointe shoreline) has been eroding at a rate varying between 60 and 90 feet per year since 1984 in response to the easterly migration of the inlet channel. If the inlet shoreline continues to migrate to the east, over the next 10 years between 36 and 51 structures could be lost or severely damaged depending upon the rate of channel migration. In addition, large portions of several streets, including Inlet Drive, Bogue Court, Inlet Court, and Channel Drive (Figure 2.2), would be lost along with public utilities serving The Pointe subdivision. If the Town and individual property owners elect to construct temporary sand bag revetments to protect threatened properties, the rate of erosion could be reduced. However, as a result of the temporary nature of the sand bag structures (due both to structural stability limitations and State of North Carolina coastal regulations for such structures) the inlet shoreline would still migrate to the east destroying an estimated 29 structures and significant portions of the associated infrastructure.



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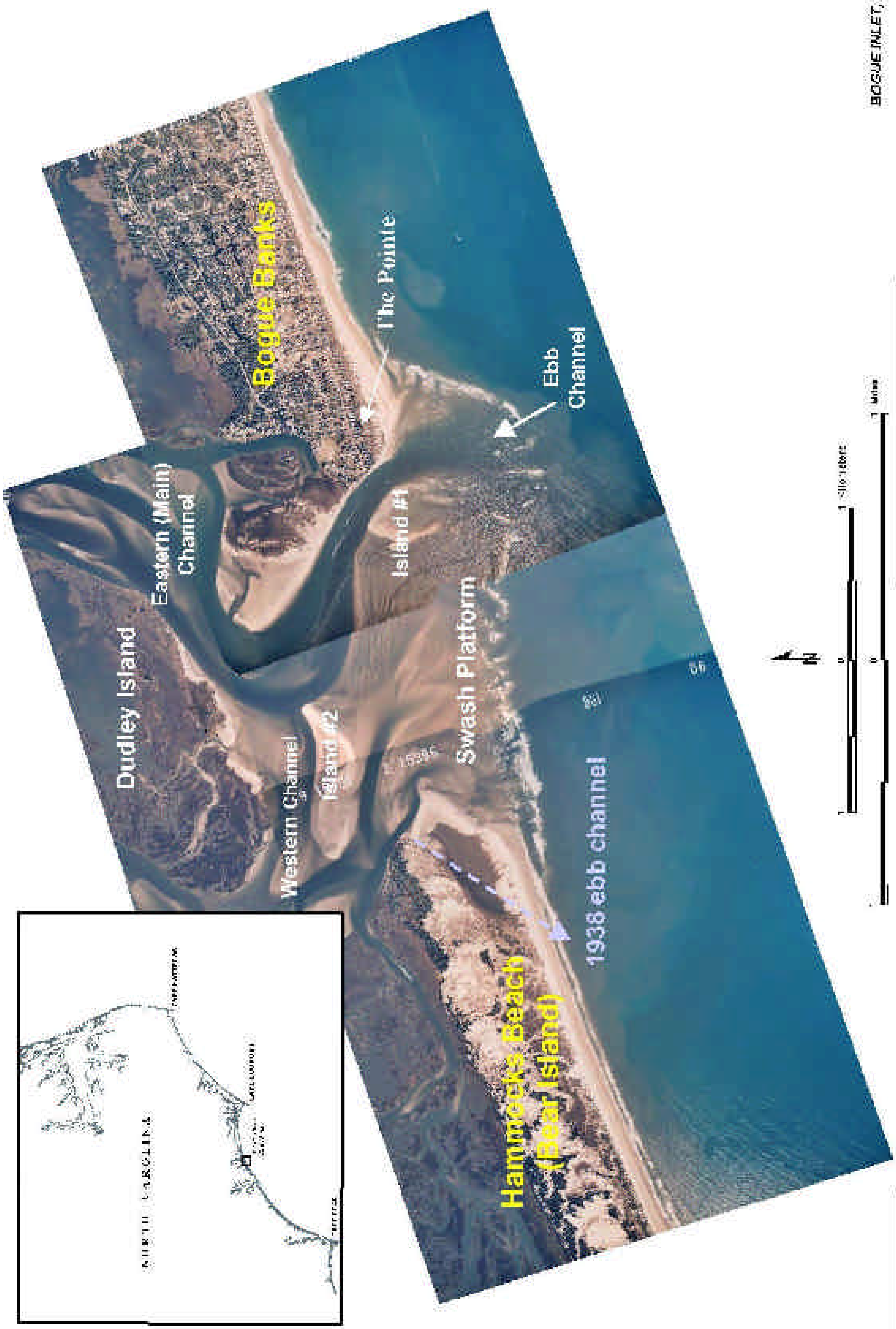
TITLE:

TOWN OF EMERALD ISLE BOGUE INLET PROJECT LOCATION MAP

DATE: 4/21/08	BY: JRC	COMM. NO.: 4500.03	FIGURE 1.1



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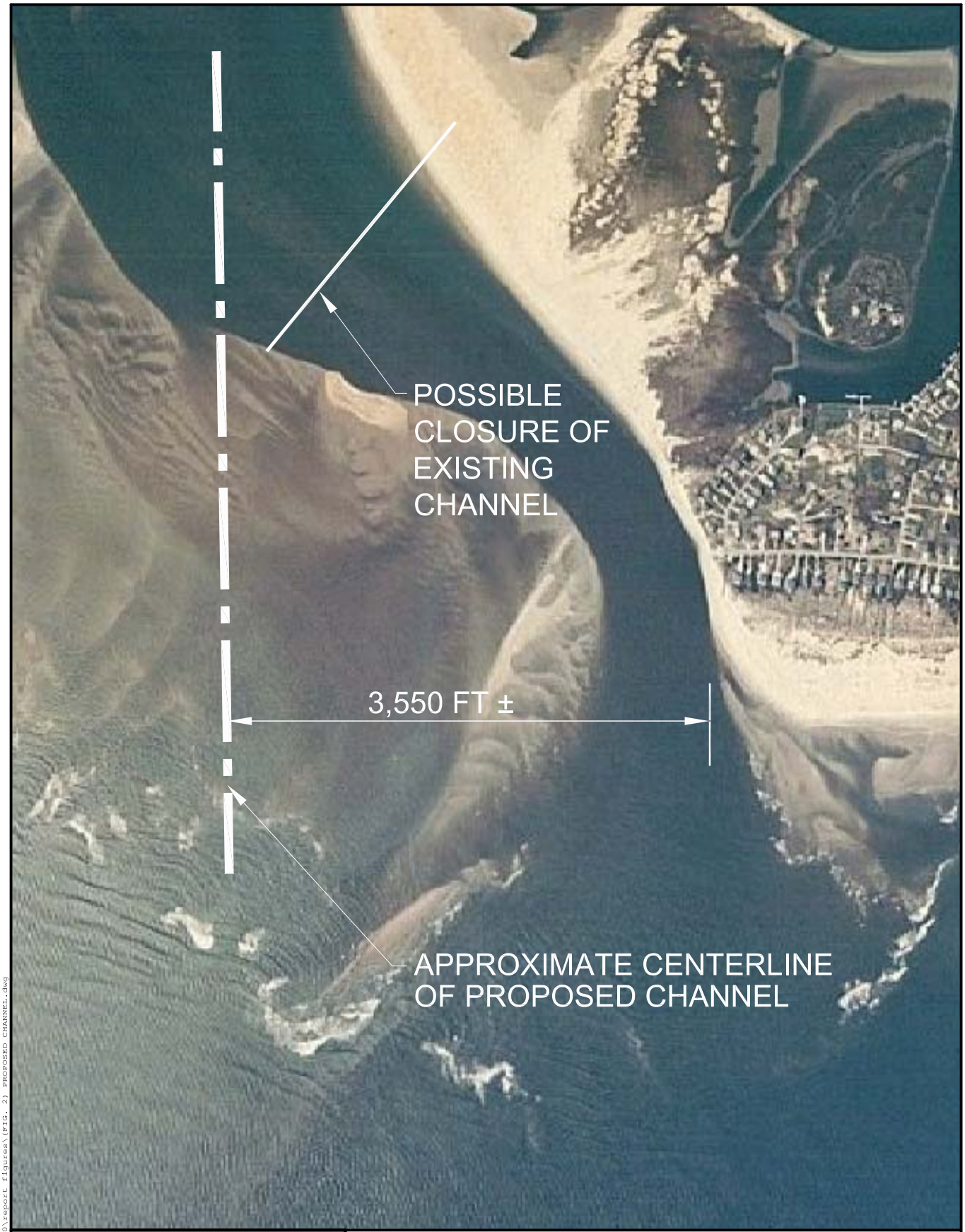
TITLE :

BOGUE INLET
SEPTEMBER 18, 2001

DATE: 10/8/02	BY: TW	COMM. NO.: 450000	FIGURE NO. 1.2



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TITLE :

APPROXIMATE CENTERLINE OF PROPOSED CHANNEL AND DIKE LOCATION

DATE: 10/8/02	BY: TW	COMM. NO.: 450000	FIGURE NO. 2.1

H:\North Carolina\450000\report figures\FIG. 2) PROPOSED CHANNEL.dwg

The proposed project design includes using a portion of the dredged material (~200,000 cubic yards) to close the existing ebb channel with the balance of the material (830,300 cubic yards) used to nourish the beach along the west end of Bogue Banks. The Town of Emerald Isle presently has permits to nourish 51,100 feet (9.7 miles) of ocean shoreline using offshore Borrow Areas A and B2 shown on Figure 2.3. The Emerald Isle beach nourishment project is part of an island-wide project sponsored by Carteret County. The County project covers approximately 16.8 miles of ocean shoreline and begins at the eastern limits of the Town of Pine Knoll Shores and extends to the west to a point 8,000 feet (1.5 miles) east of Bogue Inlet. Phase 1 of the Bogue Banks Beach Nourishment Project, completed in April 2002, included the shorelines fronting the Towns of Pine Knoll Shores and Indian Beach as well as the County owned shoreline fronting the Village of Salter Path.

The Town of Emerald Isle has divided its segment of the project into two phases. As shown on Figure 2.4, Phase 2 covers the eastern 30,600 feet of the Town's shoreline and Phase 3 the western 20,500 feet. Construction of Phase 2 of the beach nourishment project was initiated in January 2003 and was completed in April 2003. The work was accomplished using a combination of ocean certified hydraulic and hopper dredges using direct pump-out with material being obtained from the offshore borrow areas. A total of 1,819,000 cubic yards of sand has been dredged from the borrow areas and distributed along the 30,600 feet of shoreline associated with Phase 2 of the project. The design template for Phase 3 of the beach nourishment project calls for the placement of 722,000 cubic yards of sand along the 20,500 foot Phase 3 project area.

3. PLAN FORMULATION: The primary purpose of the channel relocation project is to create a stable channel that will divert tidal flow away from The Pointe shoreline area of Emerald Isle. Therefore, the design focus is on developing channel dimensions that will capture the majority of the ebb tidal flow through the inlet. An added feature of the design is the closure of the existing channel by constructing a sand dike across the waterway in the vicinity of The Pointe. It is estimated that approximately 200,000 cubic yards of material will be required to construct the dike. The balance of the material removed from the new channel will be used to nourish the west end (Phase 3) of Emerald Isle.

The main concerns with channel relocation are the impacts on the adjacent shoreline of Bear Island (Hammocks Beach State Park), which lies west of the inlet, and the shoreline on the east end of Bogue Banks (Town of Emerald Isle) as well as possible changes in the configuration of the marsh islands located north of the inlet throat. Accordingly, a detailed geomorphic analysis of the inlet was conducted to document recent changes in the inlet and adjacent shoreline associated with varying channel positions and orientations. The results of the geomorphic analysis was used to select the channel position and alignment, as well as to predict changes expected to occur in the inlet (including the adjoining marsh areas) and along the adjacent shorelines if the channel is relocated. Geotechnical investigations were conducted within the possible channel corridor to determine the characteristics of the material that would be removed to reposition the channel and determine its compatibility for use as beach nourishment along

Figure 2.2 Road Names in the Pointe Subdivision

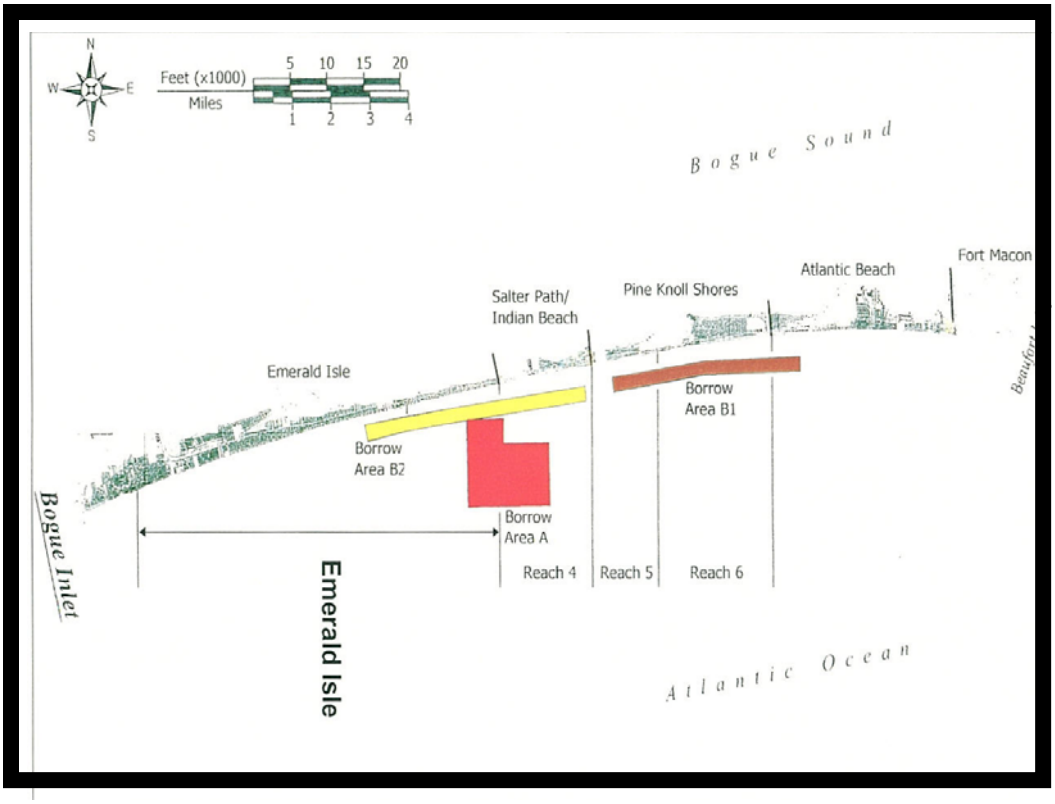

Figure 2.3 Bogue Banks Beach Nourishment Offshore Borrow Areas

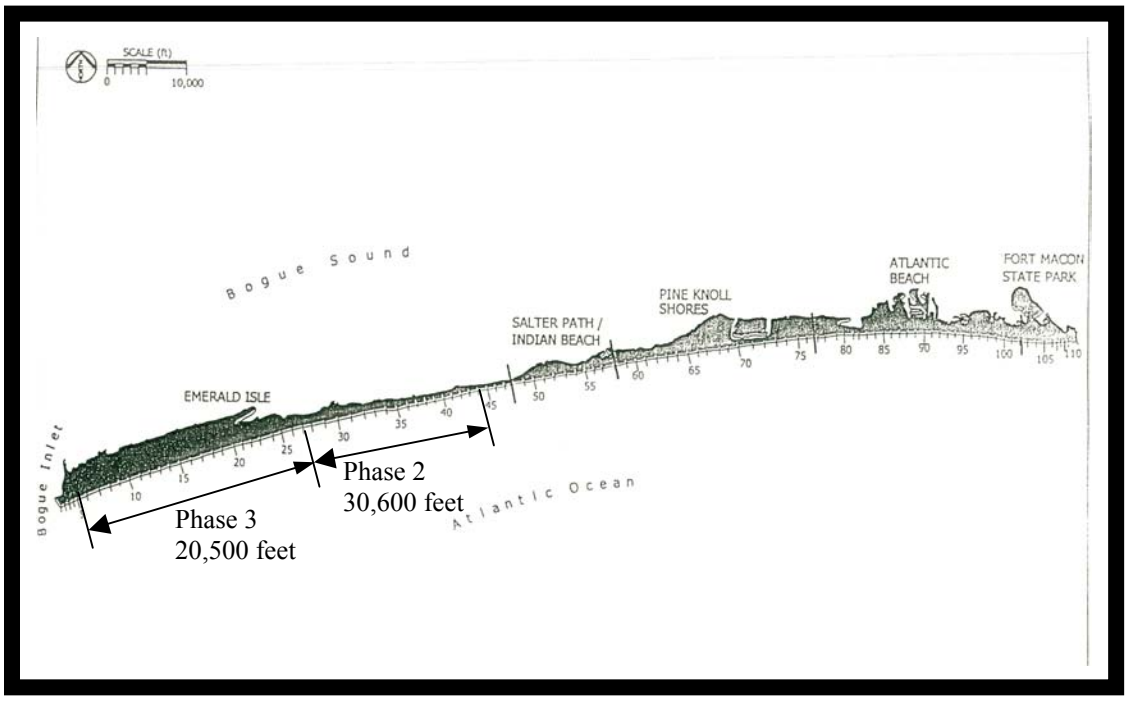

Figure 2.4 Limits of Phase 2 and Phase 3,
Emerald Isle Beach Nourishment Project

the west end of Emerald Isle. Engineering studies were undertaken to evaluate the size characteristics of the existing bar channel to determine the size of the new channel needed to capture the majority of the flow through the inlet. The hydrodynamic model was performed for the existing conditions of the inlet to establish base tidal exchange and circulation conditions within the inlet and connecting channels. The proposed channel design was modeled to develop flow and circulation patterns for comparison with the base conditions and to assess the need for, and impact of, closure of the existing channel next to The Pointe.

4. GEOMORPHIC ANALYSIS SUMMARY: Contemporary changes in the inlet and along the adjacent oceanfront shorelines were determined through analysis of a series of representative historic aerial photographs dating from 1973 through 2001. Twenty-five sets of photographs were initially examined for trends; and on the basis of these evaluations, thirteen sets of aerial photographs covering a large spatial and temporal scale (1973–2001) of Bogue Inlet, Bogue Banks, Hammocks Beach State Island (Bear Park) and neighboring marshes (Dudley Island) were analyzed. An 18,500-foot long baseline was established landward of all digitized shorelines and thirty-seven perpendicular transect lines, at 500-foot spacing were used to measure and calculate the various shoreline positions and relative changes. A second baseline was established from a stable reference position on Bogue Banks extending across the inlet to Hammocks Beach. The inlet baseline was utilized for the purpose of measuring and calculating ebb channel midpoint changes, inlet width along the baseline, and shoulder changes associated with ebb channel migration. The orientation of the ebb channel relative to the baseline was also recorded.

4.1 Ebb Channel Orientation. Over the past three decades, the orientation and position of main ebb channel has changed repeatedly, ranging from 143^{o} in February 1984 to 185^{o} in March 1999. An orientation of approximately 160^{o} is perpendicular to the general alignment of the shorelines on the adjacent islands. The movement and orientation of the outer segment of the main ebb channel, coupled with the migration of the landward segments of the channel have dictated much of the contemporary and historic shoreline change patterns along both shoulders and oceanfront shorelines.

4.2 Changes in Inlet Morphology. During the past three decades, the morphology of the inlet has changed substantially (Figures 4.1 to 4.3). Several distinct periods of change can be recognized, each with unique migration trends and morphologic characteristics. The initial phase covers the period between 1973 and 1981 when the ebb channel was moving to the west, subsequent to the shore-normal reorientation and formation of a single ebb channel in 1975. The net westward movement of the ebb channel was 1,895 feet during this initial phase of change. The second stage of inlet evolution occurred between 1981 and 1988. During this time, the single well–defined ebb channel migrated to the east approximately 830 feet (rate = 119 feet/year) and a wide marginal flood channel developed on the Bear Island shoulder. The expansion of the flood channel promoted the development of the swash platform and the mid inlet shoal. For the period from February 1984 to September 2001, the midpoint of the channel moved to the east at a rather steady rate of 93.3 feet/year. Little significant change has

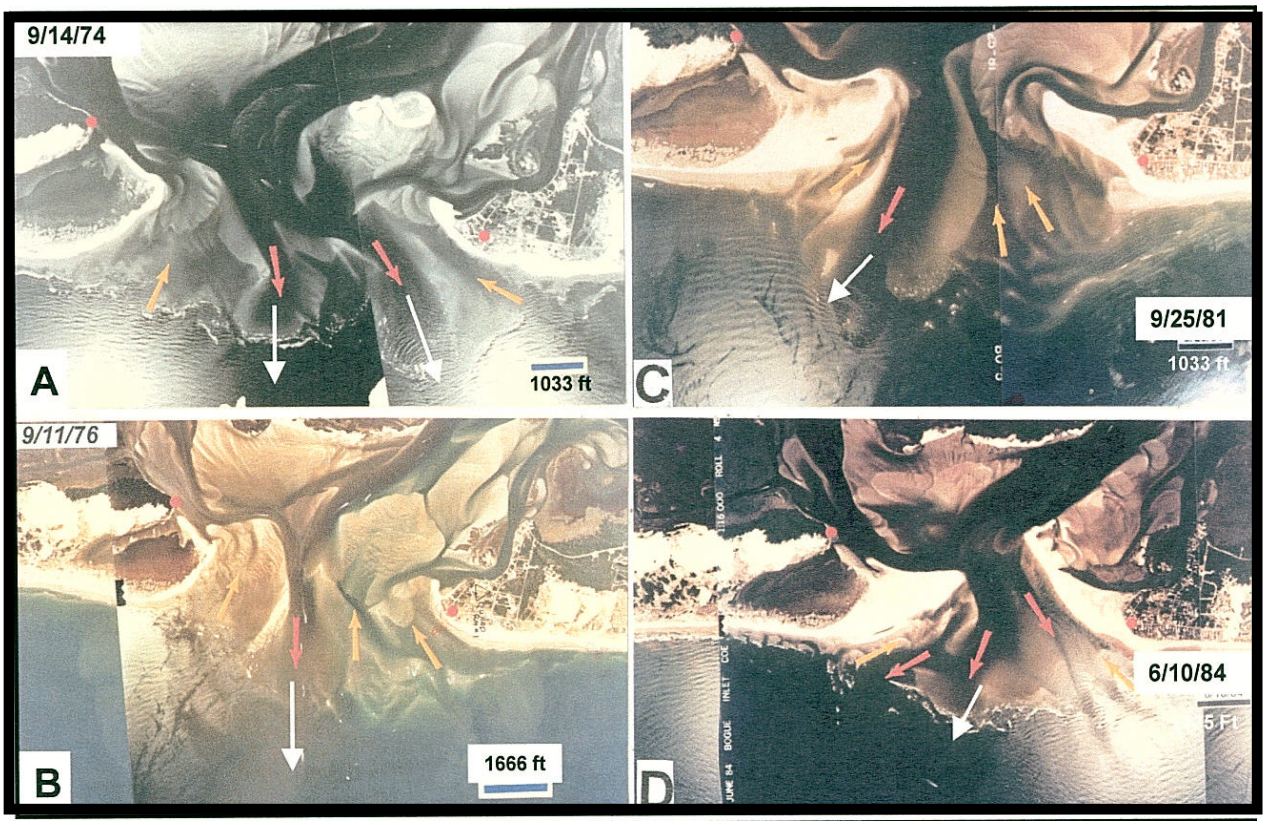

Figure 4.1 Historic aerial photographs September 1974 to June 1984 depicting inlet and shoulder configurations.

(Note: Two ebb channels present in 1974 merged into a single channel by 1976; Spit elongation on adjacent shoulders.)

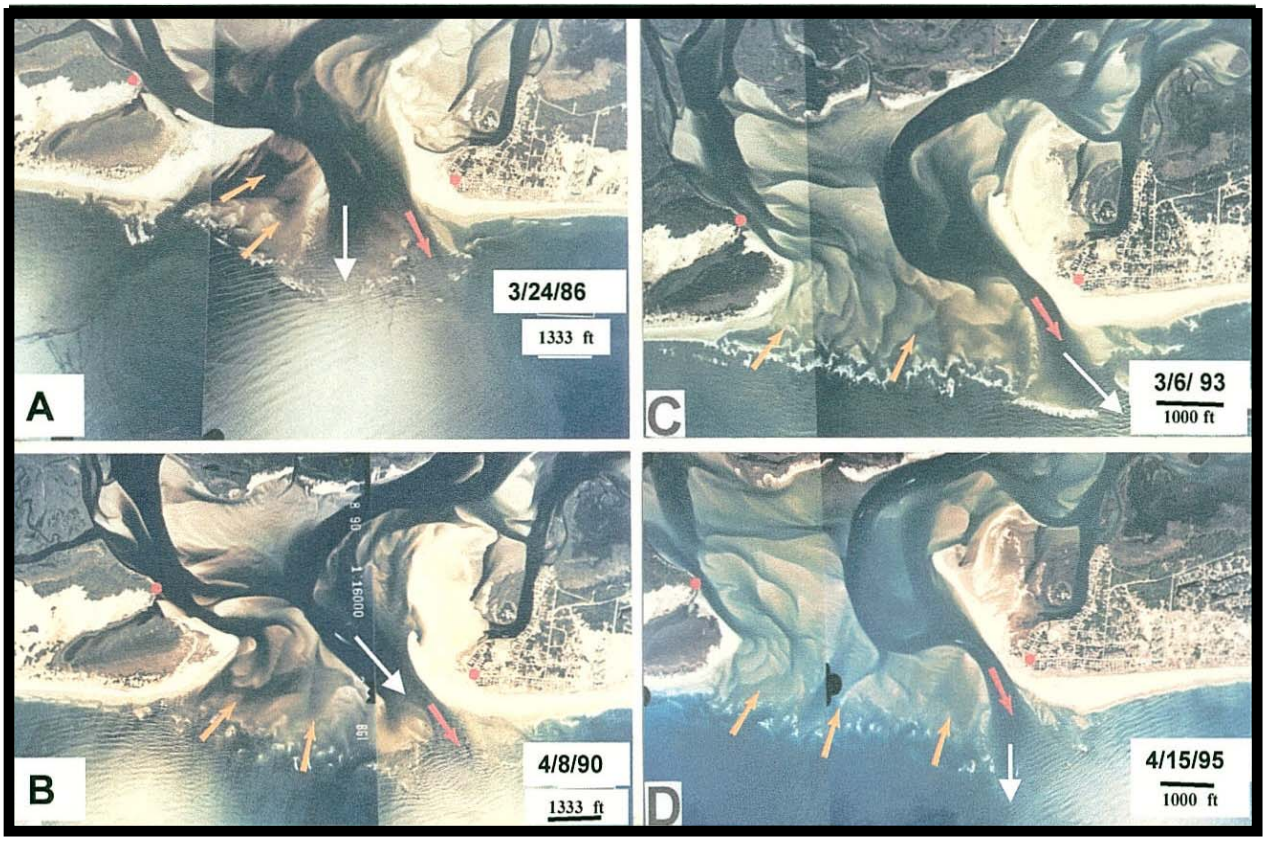

Figure 4.2 Historic aerial photographs March 1984 to April 1995 depicting inlet and shoulder configurations

(Note: The large mid inlet shoal complex and extensive swash platform, characteristics of the present inlet, began to develop in the late 1980s.)

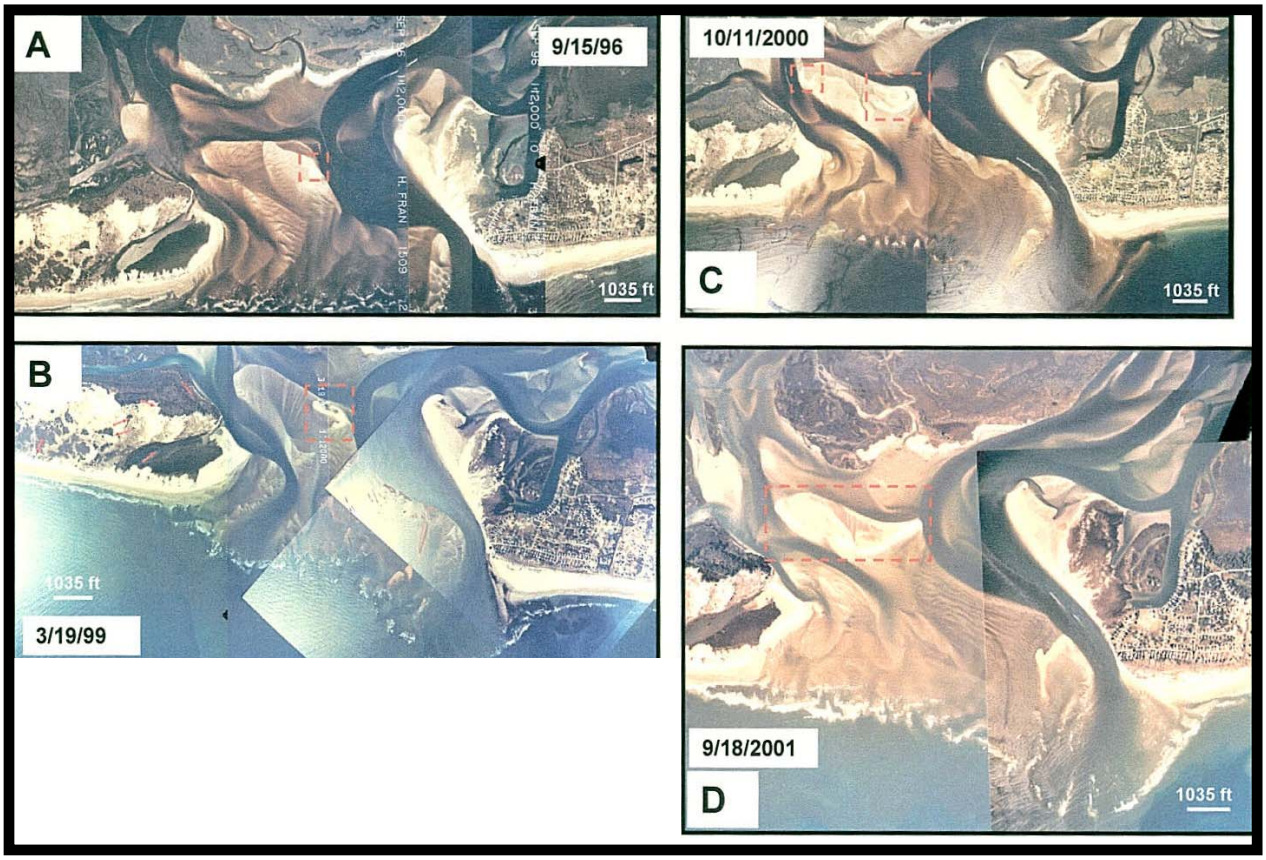

Figure 4.3 Historic aerial photographs September 1995 to September 2001 depicting inlet and shoulder configurations

(Note: The development of Islands 1 and 2 began in 1996.)

occurred in the morphology of the platform and mid inlet shoal during this interval with the exception of the emergence of ephemeral "islands" (Islands 1 and 2) that developed on the linear margin bars and in vicinity of the flood ramp (Figure 4.3). For the entire period of analysis (December 1973 to September 2001) the net movement of the ebb channel was 2,253 feet to the east at an average rate of 81.2 feet/year.

4.3 Inlet Shoreline Changes. The movement (erosion or accretion) of the east shoulder (Bogue Banks) and west shoulder (Bear Island) of the inlet generally follow a pattern of change related to the direction of movement of the channel within the inlet throat. The exception to this is a period in the mid to late 1970's when the inlet morphology was changing rapidly and adjusting to the ebb channel reorientation/repositioning that occurred in 1975.

Evaluation of the data (Figure 4.4) shows that the ebb channel reversed its movement in 1981 and began its eastward migration. Between February 1984 and September 1996, the Bogue Banks shoulder eroded 912 feet. The majority of these losses occurred between January 1994 and September 1996, a period of time characterized by increased storm activity (Hurricanes Bertha and Fran). For the period from February 1984 to September 2001, the average rate of erosion of the Emerald Isle shoreline was 62.0 feet/year. The rate of shoreline erosion appeared to accelerate between February 1992 and September 2001 during which time the average rate was 87.6 feet/year. Again, the higher rate of erosion during this more recent period may have been the result of an increase in tropical storm activity.

The pattern for the inlet shoreline changes along the Bear Island shoulder is somewhat similar to that for the Bogue Banks. The Bear Island shoulder (spit growth) initially experienced a period of accretion when the ebb channel began its easterly migration in the early 1980s. Following a period of minor erosion (183 feet) between 1973 and 1976, the western margin of the inlet prograded 1,609 feet in an easterly direction between 1976 and 1984. The recession of the Bear Island shoulder coupled with erosion of the Bogue Banks shoulder has effectively led to a general widening of the inlet throat since 1984.

4.4 Oceanfront Shoreline Change. Oceanfront shoreline changes on Bogue Banks and Hammocks Beach State Park between 1973 and 2001 for the baseline transects are depicted in Figure 4.5. During this period, there were dramatic net differences in the shoreline change patterns along Bogue Banks and Bear Island oceanfront between 1973 and 2001. The average accretion along the Bogue Banks oceanfront shoreline segment (Transects 1-14) ranged from 56 to 410 feet. The greatest shoreline accretion occurred along the oceanfront near the inlet between Transects 10 and 13 and reached a maximum of 410 feet at Transect 12. For reference purposes, Transect 11 is located near the intersection of Coast Guard Drive and Inlet Drive. The net accretion of the entire Bogue Banks shoreline is directly attributable to the eastward movement of the ebb channel over the past several decades.

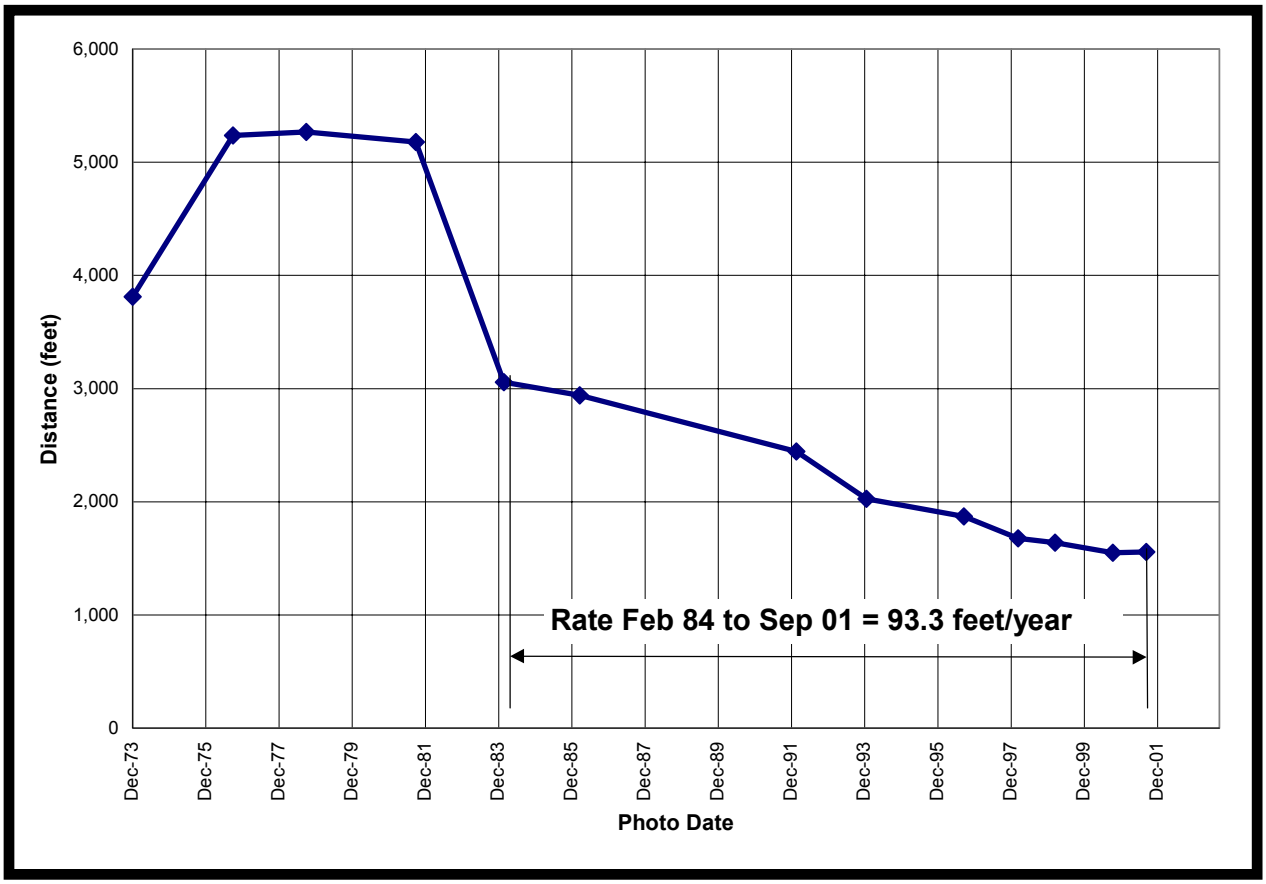

Figure 4.4 Cumulative Movement of Channel Midpoint
(Distances measured from Station 0+00 on Inlet Baseline)

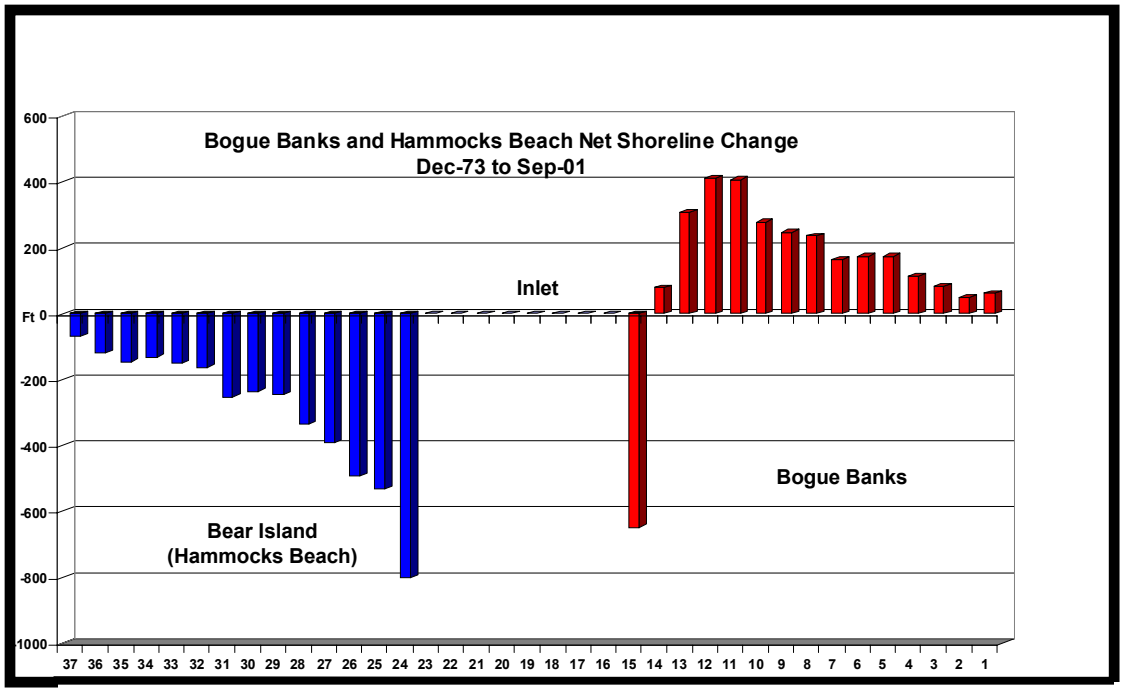

Figure 4.5 Net Oceanfront Shoreline Change along Bogue Banks and Bear Island (Hammocks Beach State Park), 1973 to 2001.

The eastward migration of the ebb channel and the attendant morphologic changes in the inlet system has not only controlled the shoreline change patterns along Bogue Banks, but concurrently they have played a significant role in the Bear Island oceanfront erosion.

4.5 Inlet Interior Island Shoreline Changes. The marsh and sandy shoreline segments that comprise the seaward portion of Dudley Island have also been significantly impacted by configuration changes in the channel/shoal system of Bogue Inlet. Segments of Dudley Island have experienced significant and rapid erosion primarily due to the eastward migration of the ebb channel; the attendant spit growth along the Bogue Banks shoulder, and the migration of the Eastern Channel toward Dudley Island. Elongation of the Bogue Banks spit and the extension of its subaqueous platform had caused the thalweg of Eastern Channel to shift toward Dudley Island, resulting in erosion and overtopping of the landward bank.

The encroachment of the Eastern Channel on the eastern portion of the marsh complex in response to the continued growth of the Bogue Banks sand spit has generally resulted in recession of the marsh shoreline located immediately to the northwest of the Bogue Banks spit. The majority of the marsh and sandy shoreline along the western portion of Dudley Island has also receded due to encroachment of various feeder channel segments. Generally, the least amount of erosion and the greatest buildup occurred north of Island 2.

Islands 1 and 2 represent small sand accumulations located within the mid inlet shoal complex. These islands are ephemeral in nature and of low relief (elevations generally less than 2 feet NGVD). Island 1 began to develop in 1995/96 along the western margin of the ebb channel. The feature increased in size and extent until 2001 but appears to have recently diminished in size as evidenced by a September 2002 aerial photograph of the inlet shown in Figure 4.6. The extremely shallow depths across the landward portion of the mid inlet shoal favored the development of Island 2 through a combination of processes associated with breaking waves and the associated swash that partially or completely overtops the low relief island. Extreme wave action during elevated water levels will likely erode a portion or the entire feature. Although no measurements were made, the eastern margin of Island 2 appears to be eroding in response to the westward movement of Eastern Channel that is occurring as a result of the growth of the Bogue Banks spit. Comparison of the September 2001 aerial photograph with that of September 2002 showed that Island 2 has migrated approximately 1,000 feet to the west.

4.6. Proposed Channel Location. The primary goal of the geomorphic analysis was to develop an understanding of the relationship between the inlet's temporal and spatial morphologic changes and the changes that occurred along the adjacent oceanfront segments since 1973. A secondary goal was to utilize this understanding to select an optimum channel location and to evaluate the impacts of the relocated channel on the various components of the system. Detailed analysis of the historic changes that have taken place since 1973 clearly show that the movement of the ebb channel and the attendant ebb-tidal delta symmetry changes are the forcing variables that dictate the erosion and accretion trends along the inlet and oceanfront shorelines of both Bogue Banks and Bear Island. The erosion of the eastern inlet shoreline in the vicinity of The

Figure 4.6 September 2002 Aerial Photograph of Bogue Inlet

Pointe and the concurrent accretion of the adjacent oceanfront shoreline on the west end of Bogue Banks are directly related to the eastward migration of the ebb channel. The data also indicates that the inlet and oceanfront erosion along adjacent Bear Island stem directly from the complex morphologic changes related to the eastward migration of the ebb channel and the associated shoal shape changes. Based on the results of this analysis, the optimal channel location is one situated within a corridor midway between the two islands with the channel oriented essentially perpendicular to the general alignment of the two islands. This optimum channel corridor corresponds to an area bounded by the 1976 and 1978 ebb channels. The proposed channel location shown on Figure 2.1 falls within this optimal channel corridor.

5. GRAIN SIZE CHARACTERISTICS: The size characteristics of the material to be removed from the inlet were compared to the size characteristics of the native beach material in order to determine the suitability and compatibility of the inlet material for use as beach nourishment. Table 5.1 provides a summary of the grain size analyses (both sieve and visual) for the samples collected from the jet probes located on or near the centerline of the proposed channel.

5.1 Jet Probes and Vibracores. Overall, the jet probes, performed in July 2002, consisted of fine to medium sand with minor amounts of shell (5 percent or less). The average mean grain size for all of the jet probe samples subjected to a sieve analysis was 0.27 mm (Table 5.1). The silt content of the jet probe samples analyzed by standard sieves was generally below 2 percent, however, since most of the fine grained material is washed out of the sediment during the jet probe process, the silt content indicated by the jet probe samples may not necessarily be indicative of the *in situ* silt content.

The results of the vibracore investigations, conducted in July 2002, indicate fairly uniform sand deposits throughout the proposed channel corridor with minor layers of shell fragments and shell hash and minimal amounts of silt. No layers of clay were observed in any of the vibracores. Silt content, as documented in both the jet probe samples and the vibracore samples had generally less than 2 percent silt (i.e., grain sizes less than 0.0625 mm).

For the Bogue Inlet/Bogue Banks area, grain sizes equal to or greater than 1 mm are generally composed of shells (King, 2002). The average amount of vibracore material with grain sizes equal to or greater than 2 mm was approximately 6% and material equal to or larger than 1 mm averaged nearly 11% for the vibracore samples. The higher concentration of coarse grain material in the vibracore samples was mostly found at depths greater than –17.5 feet NGVD. If only the samples obtained from depths equal to or less than –17.5 feet NGVD are used to determine the percent of coarse-grained material in the vibracore samples, the amount of material equal to or greater than 2 mm is about 4.5% while the percent greater than 1 mm is about 8%.

Vibracore samples were used exclusively to compute weighted composite grain size distributions for 3 channel depths; namely, -13.5 feet NGVD, -15.5 feet NGVD, and -17.5 feet NGVD. These three channel depths cover the range of optional depths that

could be recommended for the relocated channel. The results of the composite distributions for the three channel depths are summarized in Table 5.2.

Table 5.1
Grain Size Analysis for Jet Probe Samples
Jet Probes Located on or Near the Centerline of the Proposed Channel

Sample	Approx. Depth ft NGVD	Mean (mm) M_{mm}	Mean (phi) M_{phi}	Sorting S_{phi}	Variance S^2_{phi}	% Silt <230 sieve	% > 2 mm	%> 1 mm	Type of Analysis
			BIJP-02-01						
Top	-4.9	0.20	2.30	0.58	0.34	1.52	0.15	0.43	Sieve
Middle	-11.9	.18 to .25	--	--		--			Visual
Bottom	-18.9	.20 to .25	--	--		--			Visual
			BIJP-02-03						
Top	-11.7	.25 to .35	--	--		--			Visual
Middle	-18.4	.23 to .30	--	--		--			Visual
Bottom	-25.2	0.25	2.00	0.74	0.55	1.71	0.19	0.94	Sieve
			BIJP-02-05						
Top	-4.3	.23 to .27	--	--		--			Visual
Middle	-13.8	0.25	1.99	0.89	0.79	1.27	0.35	1.94	Sieve
Bottom	-23.3	.23 to .27	--	--		--			Visual
			BIJP-02-07						
Top	-3.4	0.20	2.32	0.45	0.20	1.52	0.20	0.50	Sieve
Middle	-13.4	.18 to .23	--	--		--			Visual
Bottom	-23.4	.20 to .25	--	--		--			Visual
			BIJP-02-08						
Top	-12.3	0.29	1.77	0.95	0.90	1.38	1.55	4.10	Sieve
Middle	-19.0	.30 to .40	--	--		--			Visual
Bottom	-25.8	.30 to .40	--	--		--			Visual
			BIJP-02-09						
Top	-4.5	.18 to .23	--	--		--			Visual
Middle	-12.5	0.26	1.92	0.72	0.52	1.34	0.46	1.51	Sieve
Bottom	-20.5	.20 to .25	--	--		--			Visual
			BIJP-02-11						
Top	-2.8	0.30	1.74	0.66	0.44	1.03	0.32	1.33	Sieve
Middle	-8.8	.25 to .30	--	--		--			Visual
Bottom	-14.8	.33 to .35	--	--		--			Visual
			BIJP-02-13						
Top	-3.4	.38 to .42	--	--		--			Visual
Middle	-10.4	0.35	1.52	1.10	1.21	1.53	2.64	6.97	Sieve
Bottom	-17.4	.38 to .42	--	--		--			Visual
			BIJP-02-14						
Top	-4.4	.25 to .30	--	--		--			Visual
Middle	-11.4	.20 to .25	--	--		--			Visual
Bottom	-18.4	0.30	1.75	0.78	0.61	1.39	0.93	2.75	Sieve
			BIJP-02-15						
Top	-5.4	0.36	1.49	0.65	0.42	1.14	0.06	1.01	Sieve
Middle	-13.9	.30 to .35	--	--		--			Visual
Bottom	-22.4	.33 to .38	--	--		--			Visual
			BIJP-02-16						
Top	-6.5	0.20	2.35	0.49	0.24	1.78	0.01	0.17	Sieve
Middle	-14.2	.17 to .23	--	--		--			Visual
Bottom	-22.0	.17 to .23	--	--		--			Visual
			BIJP-02-17						
Top	-5.5	.20 to .25	--	--		--			Visual
Middle	-13.5	.25 to .30	--	--		--			Visual
Bottom	-21.5	0.33	1.59	0.68	0.46	1.52	0.31	0.31	Sieve
			BIJP-02-18						
Top	-14.7	0.16	2.63	0.49		1.77	0.00	0.08	Sieve
Middle	-24.2	.17 to .23	--	--		--			Visual
Bottom	-33.7	.17 to .23	--	--		--			Visual
			BIJP-02-19						
Top	-11.4	0.36	1.48	0.90	0.81	1.93	0.65	4.27	Sieve
Middle	-19.9	.40 to .45	--	--		--			Visual
Bottom	-28.4	.30 to .35	--	--		--			Visual
Avg all Sieve Samples		**0.27**	**1.92**	**0.76**	**0.58**	**1.49**	**0.56**	**1.88**	

Table 5.2
Computed Composite Distributions 2002 Bogue Inlet Vibracores
For Channel Depths of -13.5-ft, -15.5-ft, and 17.5-ft NGVD

Depth of Cut Feet below NGVD	Phi (M_Φ)	Mean (mm) (M_{mm})	Phi Sorting (s_Φ)	Percent Silt d≤ 0.0625mm	Percent d≥ 2 mm	Percent d≥ 1 mm
-13.5	1.72	.30	1.05	1.25	4.97	8.58
-15.5	1.76	.30	0.98	1.25	4.65	8.09
-17.5	1.67	.31	1.14	1.24	4.40	7.97

5.2. Characteristics of the Native Beach Material. When beach fill material is placed on the upper portion of the beach profile, it undergoes a certain degree of sorting by wave action that tends to move discrete grain sizes to quasi-equilibrium positions on the active beach profile. In general, the coarser fraction of the material will remain on the upper or higher energy portion of the profile while the finer grained material will be transported to deeper depths. Accordingly, compatibility analyses between beach fill material and native beach material is normally carried out using composite characteristics that include samples of the native beach out to the depth of closure of the fill with the pre-project profile. Based on the wave climate in the Bogue Banks area and the configuration of the existing beach profile, the depth of closure is approximately 20 feet below MLW (-21.5 feet NGVD). The COE, as part of an island-wide Federal Storm Damage Reduction Feasibility Study, has collected samples of the native material for the entire length of the island from the base of the dune seaward to the 30-foot depth contour at 2-foot depth intervals across the profile. At the present time, the grain size analysis for these samples has not been completed. When completed, the COE samples will be used as a basis to compare the compatibility of the inlet material with the native material and determining the final overfill factor. In the interim, samples of the native beach material obtained by Coastal Science and Engineering (CSE, 2002) from the upper portion of the active profile were combined with COE samples taken in deeper depths off Atlantic Beach in 1972 to obtain an estimate of the composite grain size characteristics of the native material on the active profile. Note that the 1972 COE samples from Atlantic Beach predated the disposal of navigation maintenance material from Morehead City Harbor along this beach.

CSE collected samples from the native beaches of Bogue Banks in 1999 and 2001. A summary of the composite grain size analysis for these samples is given in Table 5.3. The samples collected by CSE were obtained from the dune, seaward to the low tide terrace (LTT). Since some of the dune material was deposited via mechanical means (bulldozing of the foreshore), the dune samples were excluded from the composite analysis of the native beach material. Also, samples collected from Station 90 on Atlantic Beach and Station 110 near the U.S. Coast Guard Station at Fort Macon, were from areas previously nourished by navigation maintenance material obtained from the Morehead City Harbor navigation project and were also excluded from the composite analysis. The composite characteristics of the foreshore material collected by CSE

Table 5.3
Analysis of Composite Characteristics for
Bogue Banks Native Sediment Samples Collected by Coastal Science & Engineering in 1999 and 2001
(Note: All Samples collected from the foreshore)

				Grain Size Distributions					
Profile # - Locality	Sample Year	Sample Location	Sample ID	Mean M_{mm} (mm)	Mean M_{phi} phi units	Max M_{phi} = **A** Min M_{phi} = **B**	Std. Dev. s_{phi} phi units	Variance $(s_{phi})^2$ (phi units)^2	
10 - Emerald Isle	1999	Berm	BB10B	0.365	1.454		0.667	0.444	
10 - Emerald Isle	1999	MBF	BB10C	0.290	1.786		0.685	0.469	
10 - Emerald Isle	1999	LTT	BB10D	0.380	1.396		0.930	0.864	
30 - Emerald Isle	1999	Dune	BB30A	0.246	2.023		0.434	0.189	
30 - Emerald Isle	1999	Berm	BB30B	0.384	1.381		0.692	0.479	
30 - Emerald Isle	1999	MBF	BB30C	0.312	1.680		0.486	0.236	
30 - Emerald Isle	1999	LTT	BB30D	0.270	1.889		0.496	0.246	
Sta 48-50 - Indian Beach	2001	Dune	B4850a	0.262	1.932		0.431	0.186	
Sta 48-50 - Indian Beach	2001	Berm	B4850b	0.266	1.911		0.400	0.160	
Sta 48-50 - Indian Beach	2001	Beach Face	B4850c	0.278	1.847		0.377	0.142	
Sta 48-50 - Indian Beach	2001	LTT	B4850d	0.460	1.120		0.844	0.712	
50 - Indian Beach	1999	Berm	BB50B	0.418	1.258		0.878	0.771	
50 - Indian Beach	1999	MBF	BB50C	0.302	1.727		0.396	0.157	
50 - Indian Beach	1999	LTT	BB50D	0.215	2.218	**A**	0.529	0.280	
Sta 52-54 - Indian Beach	2001	Dune	B5254a	0.250	2.000		0.450	0.203	
Sta 52-54 - Indian Beach	2001	Berm	B5254b	0.224	2.158		0.385	0.148	
Sta 52-54 - Indian Beach	2001	Beach Face	B5254c	0.314	1.671		0.567	0.321	
Sta 52-54 - Indian Beach	2001	LTT	B5254d	0.329	1.604		0.692	0.479	
Sta 56-58 - Indian Beach	2001	Dune	B5658a	0.321	1.639		0.653	0.426	
Sta 56-58 - Indian Beach	2001	Berm	B5658b	0.227	2.139		0.480	0.230	
Sta 56-58 - Indian Beach	2001	Beach Face	B5658c	0.348	1.523		0.404	0.163	
Sta 56-58 - Indian Beach	2001	LTT	B5658d	0.374	1.419		0.798	0.637	
Sta 60-62 - Pine Knoll Shores	2001	Dune	B6062a	0.500	1.000		0.839	0.704	
Sta 60-62 - Pine Knoll Shores	2001	Berm	B6062b	0.274	1.868		0.377	0.142	
Sta 60-62 - Pine Knoll Shores	2001	Beach Face	B6062c	0.347	1.527		0.713	0.508	
Sta 60-62 - Pine Knoll Shores	2001	LTT	B6062d	0.346	1.531		0.773	0.598	
Sta 64-66 - Pine Knoll Shores	2001	Dune	B6466a	0.310	1.690		0.444	0.197	
Sta 64-66 - Pine Knoll Shores	2001	Berm	B6466b	0.231	2.114		0.460	0.212	
Sta 64-66 - Pine Knoll Shores	2001	Beach Face	B6466c	0.293	1.771		0.360	0.130	
Sta 64-66 - Pine Knoll Shores	2001	LTT	B6466d	0.382	1.388		0.924	0.854	
Sta 68-70 - Pine Knoll Shores	2001	Dune	B6870a	0.245	2.029		0.492	0.242	
Sta 68-70 - Pine Knoll Shores	2001	Berm	B6870b	0.222	2.171		0.370	0.137	
Sta 68-70 - Pine Knoll Shores	2001	Beach Face	B6870c	0.422	1.245		0.886	0.785	
Sta 68-70 - Pine Knoll Shores	2001	LTT	B6870d	0.348	1.523		0.723	0.523	
70 - Pine Knoll Shores	1999	Berm	BB70B	0.338	1.565		0.821	0.674	
70 - Pine Knoll Shores	1999	MBF	BB70C	0.475	1.074		0.952	0.906	
70 - Pine Knoll Shores	1999	LTT	BB70D	0.288	1.796		0.580	0.336	
Sta 72-74 - Pine Knoll Shores	2001	Dune	B7274a	0.279	1.842		0.624	0.389	
Sta 72-74 - Pine Knoll Shores	2001	Berm	B7274b	0.258	1.955		0.421	0.177	
Sta 72-74 - Pine Knoll Shores	2001	Beach Face	B7274c	0.326	1.617		0.897	0.805	
Sta 72-74 - Pine Knoll Shores	2001	LTT	B7274d	0.268	1.900		0.697	0.486	
Sta 76-78 - Pine Knoll Shores	2001	Dune	B7678a	0.233	2.102		0.462	0.213	
Sta 76-78 - Pine Knoll Shores	2001	Berm	B7678b	0.236	2.083		0.346	0.120	
Sta 76-78 - Pine Knoll Shores	2001	Beach Face	B7678c	0.492	1.023	**B**	0.938	0.880	
Sta 76-78 - Pine Knoll Shores	2001	LTT	B7678d	0.293	1.771		0.744	0.554	
90 - Atlantic Beach	1999	Dune	BB90A	0.234	2.095		0.415	0.172	
90 - Atlantic Beach	1999	Berm	BB90B	0.228	2.133		0.498	0.248	Stations 90 & 110
90 - Atlantic Beach	1999	UBF	BB90C	0.244	2.035		0.667	0.444	in beach nourishment
90 - Atlantic Beach	1999	LTT	BB90D	0.243	2.041		0.653	0.426	area and were excluded
110 - Coast Guard Station	1999	Dune	BB110A	0.801	0.320		1.211	1.466	from composite
110 - Coast Guard Station	1999	Berm	BB110B	0.541	0.886		0.960	0.922	analysis
110 - Coast Guard Station	1999	MBF	BB110C	0.457	1.130		1.083	1.173	
110 - Coast Guard Station	1999	LTT	BB110D	0.200	2.322		0.739	0.547	
Averages [(a)]				$(M_{phi})_{ave}$ =	1.670		$((s_{phi})^2)_{ave}$ =	0.438	

[(a)] Samples in gray excluded from composite analysis

Composite Variance = $s_c^2 = (s_{phi})^2)_{ave} + ((B-A)^2)/12$ = 0.438 + $(1.023 - 2.218)^2/12$ 0.557

Summary Composite of CSE Native Sediment Samples

Composite Variance	s_c^2 =	0.557	$(phi)^2$
Composite Standard Deviation	s_c =	0.746	(phi)
Composite Mean (phi units)	M_{phi}	1.670	(phi)
Composite Mean (mm)	M_{mm}	0.314	(mm)

(composite of three samples collected at each sampling station) has a mean grain size of 1.67Φ (phi) or .31 mm and a sorting coefficient (standard deviation) of 0.746Φ. The resulting composite characteristics of the native sand (Table 5.4) from the foreshore seaward to -20 feet MLW has a mean grain size of 2.4Φ (.19 mm) and a standard deviation of 0.73Φ.

The characteristics of all three channel depth alternatives indicate that the Bogue Inlet material is highly compatible with the native beach material. This is expected considering that the ebb tide delta is composed primarily of material derived from the adjacent beaches. Apart from the compatibility of the grain sizes, when material is removed from a borrow area and deposited on a beach, there are inherent differences in the volume of material removed from the borrow area compared to the volume that can be measured on the beach. Much of this difference is due to measurement error and a factor commonly referred to as shrinkage. Based on past experience, the difference between borrow area volume and the volume of sediment retained on the beach generally ranges from ten to twenty percent. Since the material in Bogue Inlet is highly compatible with the native beach material, the total overfill factor used for beach fill quantity estimates is 1.15. For an overfill factor of 1.15, the total or gross volume of material that would be required to satisfy the beach nourishment requirements for Phase 3 of the Emerald Isle Beach Nourishment Project would be 830,300 cubic yards.

6. DESIGN OF THE RELOCATED CHANNEL: The proposed centerline of the new channel would be located approximately 3,400 feet west of Inlet Drive. If the new channel undergoes similar changes as exhibited by the existing channel between 1981 and 2001, the channel could return to its existing location in about sixteen years. If the new channel does not make an initial dramatic move to the east after relocation and migrates at the rate documented between February 1984 and September 2001, the channel would not return to its 2003 position for nearly thirty-seven years.

As discussed earlier, the primary purpose of the channel relocation project is to create a stable channel that will capture the majority of the flow through the inlet and divert flow away from The Pointe area of Emerald Isle. If the relocated channel is too small, frictional forces could prevent velocities in the channel from attaining magnitudes necessary to flush littoral sediment out of the channel resulting in the eventual closure of the new channel. Although the channel may be large enough to capture the flow, initial adjustments in the channel cross-sectional area immediately following construction could lead to excessive scour with possible deposition of the scoured material in the ebb tidal delta, connecting channels, adjacent marshes, and wetland areas.

If the channel is excessively large, it will gradually shoal to a more stable cross-section. However, during the period of adjustment, the tidal prism of the inlet (i.e., the total volume of water that flows through the inlet during an ebb of flood cycle) could be increased. Furthermore, the material required to shoal the channel could adversely impact the sediment balance on the adjacent beaches. Therefore, the design focus was on developing the proper size channel that would be large enough to remain open without an excessive amount of shoaling yet small enough to not cause excessive scour. The design

Table 5.4
Corps of Engineers Samples of Native Beach Material from Atlantic Beach, NC
Prior to disposal of navigation material on Atlantic Beach
Sample date 1972 and
Composite Native Beach Characteristics Based on Combined COE and CSE Samples

	Profile 70+00			Profile 140+00			Profile 219+00			Profile 290+00		
Sample	Mean (M)	Std.Dev. (s	Variance	Mean (M)	Std.Dev. (s	Variance	Mean (M)	Std.Dev. (s	Variance	Mean (M)	Std.Dev. (s)	Variance
Elev. Mlw	phi units	phi units	(s^2)	phi units	phi units	(s^2)	phi units	phi units	(s^2)	phi units	phi units	(s^2)
Top Berm	2.53	0.30	0.09	2.28	0.45	0.20	2.45	0.30	0.09	2.18	0.38	0.14
6	2.37	0.38	0.14	2.57	0.52	0.27	2.33	0.40	0.16	2.03	0.46	0.21
4	2.58	0.27	0.07	2.38	0.35	0.12	2.50	0.31	0.10	1.94	0.70	0.49
2	2.25	0.44	0.19	2.18	0.40	0.16	2.13	0.36	0.13	1.97	0.41	0.17
0	1.66	0.87	0.76	1.83	0.75	0.56	1.72	0.52	0.27	0.34	1.37	1.88
-2	1.80	0.86	0.74	1.91	0.81	0.66	1.61	0.80	0.64	1.76	0.82	0.67
-4	2.59	0.39	0.15	2.19	0.59	0.35	2.71	0.46	0.21	2.48	0.51	0.26
-6	2.38	0.47	0.22	2.15	0.57	0.32	2.57	0.55	0.30	2.85	0.43	0.18
-8	2.57	0.38	0.14	2.52	0.40	0.16	2.37	0.54	0.29	2.56	0.56	0.31
-10	1.56	0.78	0.61	2.97	0.34	0.12	2.92	0.35	0.12	3.08	0.37	0.14
-12	1.31	0.60	0.36	3.10	0.35	0.12	3.02	0.42	0.18	3.01	0.48	0.23
-14	2.52	0.45	0.20	3.10	0.35	0.12	3.07	0.36	0.13	3.02	0.42	0.18
-16	2.36	0.52	0.27	3.07	0.39	0.15	3.11	0.37	0.14	3.08	0.42	0.18
-18	2.49	0.49	0.24	3.08	0.38	0.14	3.09	0.40	0.16	3.05	0.44	0.19
-20	2.45	0.50	0.25	3.05	0.41	0.17	3.12	0.38	0.14	3.06	0.43	0.18
-22	2.47	0.52	0.27	3.00	0.42	0.18	3.06	0.43	0.18	3.02	0.46	0.21
-24	2.86	0.34	0.12	3.01	0.41	0.17	3.00	0.49	0.24	2.79	0.68	0.46
-26	2.67	0.43	0.18	3.04	0.39	0.15	2.77	0.75	0.56	2.85	0.72	0.52
-28	2.59	0.52	0.27	2.33	1.05	1.10	2.25	1.21	1.46	2.59	0.87	0.76
-30	2.18	0.52	0.27	2.49	0.54	0.29	2.73	0.78	0.61	2.58	0.90	0.81

Composite Characteristics of COE Samples between -2 feet and -20 feet

Samples from -2 to -20 feet

composite Mean = M 2.62 phi 0.16 mm

s^2 = 0.26

s = 0.51 phi

A = 1.31

B = 3.12

composite variance = $s^2_{comp} = s_c^2 = s^2 + ((B-A)^2)/12$

s^2_{comp} = 0.53

s_{comp} = 0.73

Weighted Average for CSE & COE Samples

CSE average of 3 samples collected from foreshore of each sample station
COE average of 10 samples collected between -2 feet and -20 feet

Weighted Mean = $((M_{CSE} \times 3) + (M_{COE} \times 10))/13$ = 2.40 phi
0.189 mm

Weighted Var = $((s^2_{CSE} \times 3) + (s^2_{COE} \times 10))/13$ = 0.536 $(phi)^2$

Weighted Standard Deviation = 0.732 phi

for the relocated channel included consideration of the size characteristics of the existing ebb tide channel, numerical model studies of tides and currents in the inlet, and channel shoaling/stability criteria. An added feature of the overall design of the channel relocation project is the closure of the existing channel by constructing a sand dike in the vicinity of The Pointe. Numerical modeling was also used to evaluate the impacts of closing the existing channel on flow patterns in the system and to assess the impacts of the proposed inlet modifications on flow circulation throughout the inlet complex.

6.1. Design of Channel Cross-Section. The existing ebb channel through the inlet follows a circuitous route (Figure 1.2) from Dudley Island past The Pointe and across the ebb tidal delta. The cross-sectional area of the existing ebb channel also varies markedly. As a result of the variable dimensions of the existing channel, the proposed cross-sectional area of the relocated channel will have a variable cross-section as it projects seaward across the ebb tidal delta. The variable cross-section will be accomplished by varying the bottom width of the channel at given depths. Two sets of variable bottom widths were evaluated (Table 6.1), one with a maximum width of 400 feet and the other with a maximum width of 500 feet.

Table 6.1
Proposed Variable Channel Bottom Widths

Stations (feet)	Maximum Bottom Width 400-feet	Maximum Bottom Width 500-feet
0+00 to 25+00	150 feet	150 feet
25+00 to 35+00	Width increased from 150 feet to 400 feet	Width increased from 150 feet to 500 feet
35+00 to 55+00	400 feet	500 feet
55+00 to 60+00	Width decreases from 400 feet to 200 feet	Width decreases from 500 feet to 200 feet
60+00 to End	200 feet	200 feet

Due to the shallow depths that exist across the ebb tidal delta, the only practical way to relocate the channel is with an ocean certified cutter-suction pipeline dredge. These dredges have a minimum operational depths of approximately 12 feet. Therefore, the minimum channel depth considered was 13.5 feet below NGVD (-12.0 feet MLW) with incremental depths of 15.5 feet NGVD and 17.5 feet NGVD also evaluated. The side slopes of the channel specified for construction will be 1 vertical to 5 horizontal (1V:5H), however, as discussed below, the ultimate side slopes that the new channel will assume will be much flatter.

Repositioning of the inlet channel combined with the closure of the existing channel next to The Pointe, either by the deposition of naturally transported littoral sediment or

through direct placement of dredged material, will reduce or completely eliminate flows in the existing channel. The remnants of the existing channel will shoal and a new sand spit will develop off the west end of Emerald Isle. With a properly sized channel, the flow diverted from the existing channel will be funneled through the new channel and the flow areas across the ebb tidal delta will adjust to areas comparable to the existing flow areas. The adjustments likely to occur following the construction of the new channel would include the flattening of the channel side slopes from 1V:5H to between 1V:20H and 1V:50H, which are comparable to those of the existing channel. Construction slopes flatter than 1V:5H are not practical given the operational constraints associated with an ocean certified pipeline dredge. The formation of a channel side slope during construction is generally the result of material sloughing as the dredge undercuts the bank. As a result of the post-construction adjustments, the new channel would assume the same characteristics as the existing bar channel. Figure 6.1 shows a hypothetical sand spit that is expected to form off the west end of Emerald Isle, the general location of the proposed sand dike and the seaward portions of the existing channel that would naturally shoal following channel relocation.

6.2 Sand Dike Alternatives With the new channel assuming the majority of the flow, the final adjustments in the inlet's cross-sectional area will be the same with or without the sand dike across the existing ebb channel. However, the time required for the adjustments to occur will be somewhat longer without the dike as residual flow would continue to occur in the existing channel thus slowing the rate of shoaling. There is also some degree of uncertainty that the new channel would become the dominant channel if the existing channel is not closed immediately.

Without the sand dike, the existing channel would eventually be filled with sediment derived from the west end of Emerald Isle and the collapse of the ebb tide delta. A total of 1,493,000 cubic yards of sediment would be needed to completely fill the existing channel over a period of four to six years. This volume represents approximately 72% of the sediment expected to be eroded from the west end of Emerald Isle or transported onshore from the collapse of the ebb tide delta. If a sand dike is constructed across the existing channel in the vicinity of cross-section 35+00 as shown on Figure 6.1, 1,006,000 cubic yards would initially be deposited in the channel area seaward of the dike with an additional 184,000 cubic yards eventually working its way to the channel area landward of the dike. With closure of the existing channel, longshore transport would be essentially unimpeded by tidal currents as would the onshore movement of the abandoned ebb tide delta material. In this case, the existing channel is expected to be almost completely filled in two years with the sand spit rapidly forming off the west end of Emerald Isle.

Model simulations found the following conclusions regarding the sand dike:

- The new channel alignment will increase flow through the center of the inlet complex. However, without a closure of the existing channel, there will still be a substantial concentration of flow adjacent to Emerald Isle. The concentration of flow near the southern bank of Dudley Island will remain.

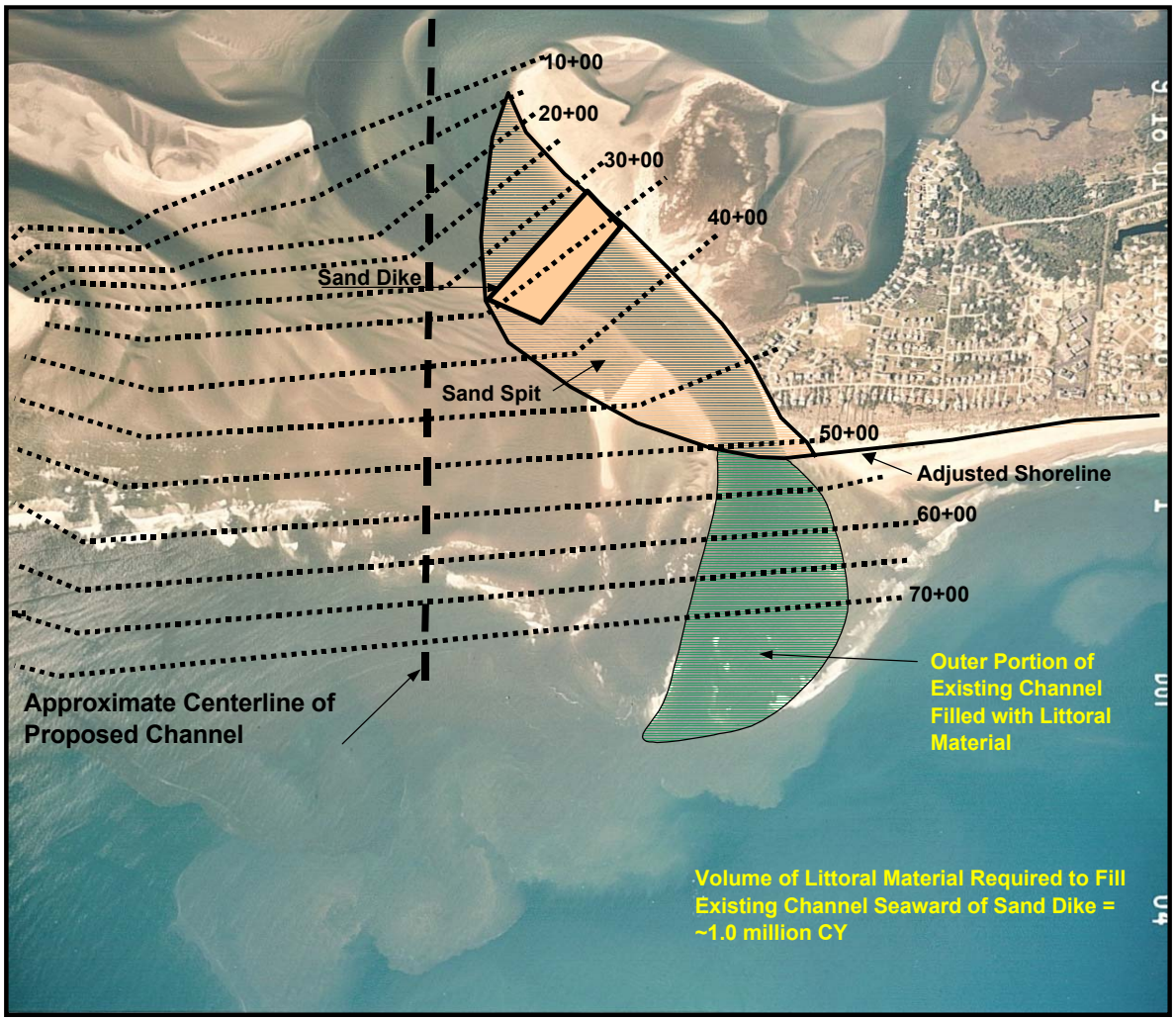

Figure 6.1 Cross-Section Locations and Adjusted Shoreline Conditions Following Channel Reloaction

- Velocities in the existing channel can be reduced sufficiently by constructing a dike to close the channel and raising the elevation of the Emerald Isle sand spit to at least +3 feet NGVD.

- The relocation of the channel with a dike will change the overall distribution of flow with a higher percentage of the total flow passing through the Dudley Island Channel and the Eastern Channel. The Dudley Island Channel will become an ebb-dominated channel compared to its present flood dominance while the Eastern Channel will continue to be ebb-dominant.

Closure of the existing ebb channel by the construction of a sand dike with dredged material will significantly reduce the likelihood of additional erosion along the inlet shoulder in the vicinity of The Pointe. Numerical Model results indicate that some of the flow would persist in the existing channel for a period of time even with the construction of a sand dike. However, these persistent flows would have low velocities and should not negatively impact The Pointe shoreline. A sand dike would forcibly redirect the ebb flow toward the new channel and aid in the demise and abandonment of the former ebb channel. The cessation or reduction of ebb tidal flow in the existing channel would accelerate the reorganization and eventual collapse of the fronting ebb delta segment. The relatively rapid landward transport of the materials comprising the shoal segment would result in rapid spit growth on the Bogue Banks shoulder and infilling of the seaward portion of the former ebb channel. The aforementioned post-relocation scenario will also involve transport of sand into the estuary through the marginal flood channel that will develop between the newly relocated ebb channel and the eastern shoulder. The redevelopment of the sand spit on the west end of Emerald Isle will take four to six years with the spit eventually merging with the sand dike. Once the new spit reaches the sand dike, material will be transported past the dike and the spit will reconnect with the existing sand spit landward of the dike. During this period of evolution, the eastern channel should remain stable thus easing some of the erosion of the Dudley Island marsh. However, once the spit has completely reformed and merged with the existing spit, erosion of Dudley Island may continue.

7. **CHANNEL SHOALING ANALYSIS**: Immediately following relocation of the inlet channel, adjustments will begin to occur with some shoaling expected along the interior portions of the channel and scour in the outer sections. Following these initial changes, the new channel will begin to behave as an artificially deepen channel constructed across the inlet's ebb tide delta. In this regard, the depths and width characteristics of an inlet ocean bar channel are dictated by prevailing currents, tides, wave action and, sediment transport. When an artificially deep or wide channel is cut through the ebb tide delta, these factors will immediately begin to work toward restoring the dimensions of the channel to its natural depth and width.

8. **RECOMMENDED CHANNEL ALTERNATIVE:** Based on the results of the geomorphic analysis of the inlet, model studies, and channel stability analysis, closure of the existing channel will be necessary to assure the success of the project and accelerate the recovery of The Pointe shoreline and associated intertidal habitat. Also, with respect

to the dimensions of the new channel, all six alternatives evaluated would satisfy the stability criteria, particularly with the closure of the existing channel. The only channel alternative that appeared to be marginally acceptable was the -13.5 ft NGVD x 400 ft channel, which would result in an overall inlet cross-sectional area very close to the critical area. Accordingly, in order to provide some degree of safety, the next smallest channel evaluated, i.e., the -13.5 ft NGVD x 500 ft channel was selected. This channel is deemed to be the minimum channel needed to completely satisfy the inlet stability criteria and will result in less scour than the 13.5 ft NGVD x 400 ft channel during the initial readjustment period immediately following the construction of the channel.

8.1. Physical Impacts of Channel Relocation: Relocation of the ebb channel to a mid inlet location will alter the sediment transport patterns on both shoulders and ultimately result in the reconfiguration of the ebb tidal delta. After an initial period of adjustment, the apex of the ebb delta will eventually shift between 2,500 and 3,000 feet in a westward direction. During this initial period of equilibration, which may last two years or more, a significant volume of the ebb-tidal flow will be redirected from the erosion hot spot along the eastern shoulder of the inlet to the new channel.

8.2. Shoreline Adjustments on Bogue Banks. Given sufficient time, the oceanfront shoreline along Bogue Banks will erode and recede to a position that is approximated by the location of the 1978 shoreline. Based on the amount of accretion that occurred on Bogue Banks between 1978 and 2001, the shoreline recession that could occur as a result of the channel relocation project along various segments on the west end of Bogue Banks are as follows:

Table 8.1
Estimated Erosion Rates West End of Bogue Banks

	Average Erosion[(a)]	Maximum Erosion
Transects 1 to 5	-10 feet	-80 feet
Transects 6 to 10	-150 feet	-300 feet
Transects 11 to 13	-350 feet	-400 feet

[(a)] Note: Average erosion rates rounded from those presented in Section 4.

Figure 8.1 graphically depicts the average anticipated shoreline recession and the maximum expected recession that could occur following the relocation of the Bogue Inlet ebb channel. As shown in Figure 8.1, the predicted shoreline recessions would position the adjusted shoreline slightly seaward of the primary dune system.

8.3. Estimated Volumetric Erosion – Emerald Isle. The COE performed offshore profiles along Bogue Banks in April 2001. Six of the profile stations were in the area expected to undergo adjustments following the relocation of the Bogue Inlet channel. The approximate locations and numbering of these six profile stations are shown on Figure 8.2. Profile station 1252+76 is located near the east limit of expected shoreline adjustments and appears to be outside the influence of the Bogue Inlet ebb tide delta.

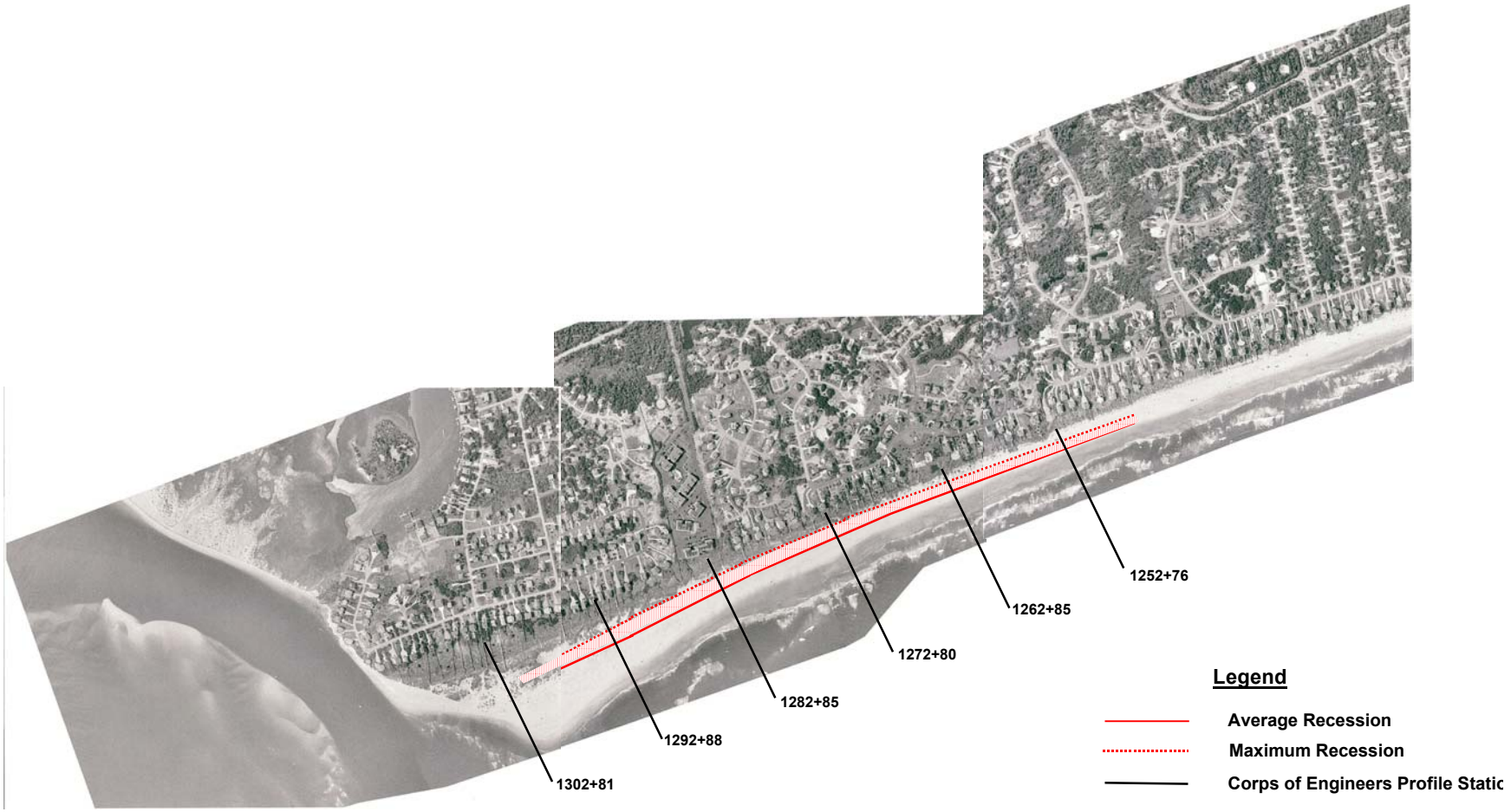

Figure 8.1 Possible Range of Shoreline Adjustments following Relocation of the Bogue Inlet Ebb Channel

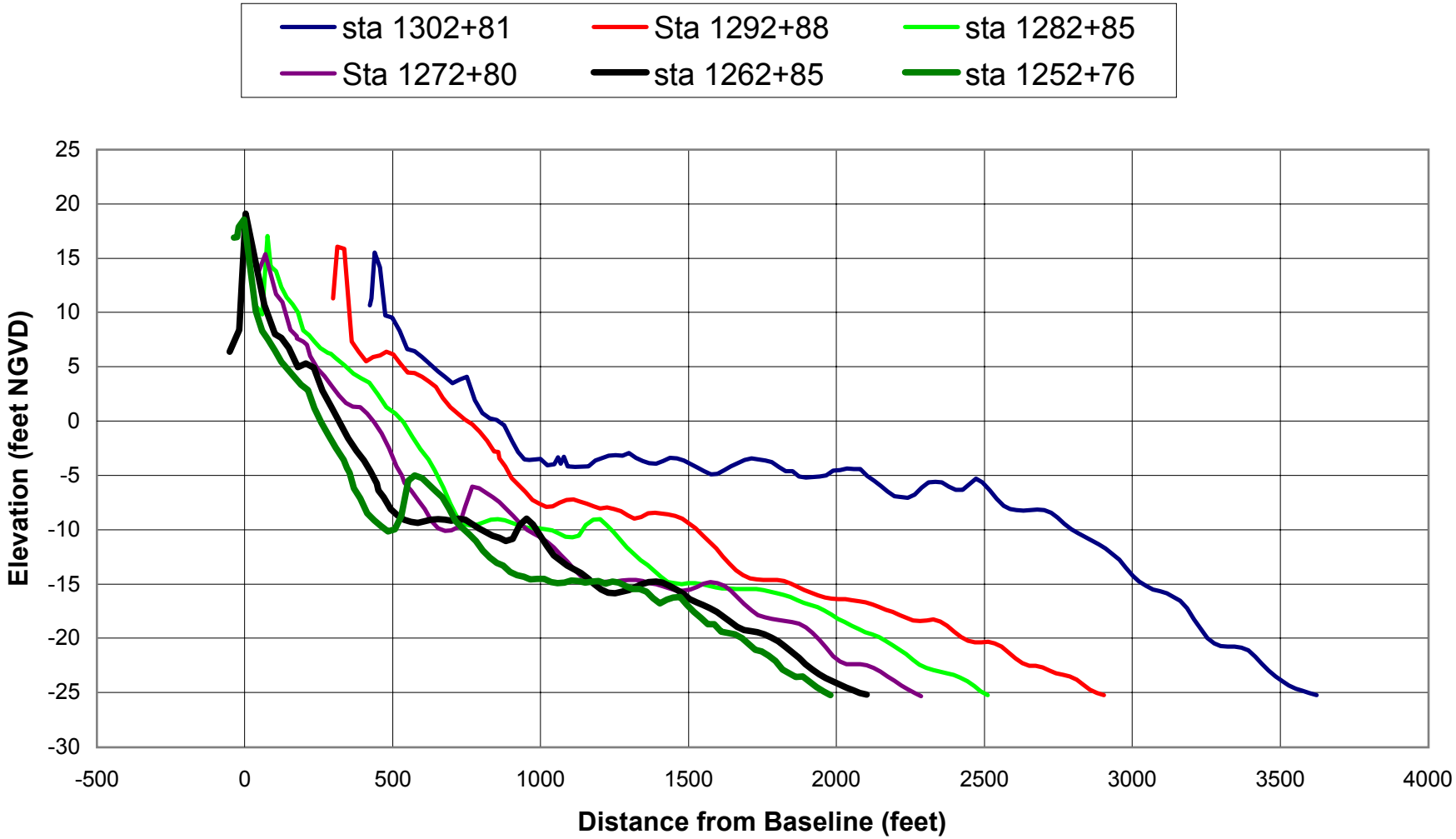

Figure 8.2 April 2001 Corps of Engineers Profiles West End of Emerald Isle

Accordingly, the shape of the profile at station 1252+76 was used to represent the shape that the other profiles would assume following the channel relocation. The adjusted profile at the other 5 stations was estimated based on the predicted erosion of the shoreline following the channel relocation. The adjusted profiles for the 5 stations are shown on Figure 8.3. The volume of material represented by these assumed profile adjustments was estimated to be 2,065,000 cubic yards.

8.4. Time Required for Shoreline Adjustments on the West End of Emerald Isle. Erosion and redistribution of this material may take a considerable amount of time. However, not all of this material would be transported out of the area by longshore transport processes since approximately 1.5 million cubic yards (located between baseline stations 1282+85 and 1302+81) is associated with the portion of the ebb tidal delta that would be abandoned following the relocation of the channel. The remaining 565,000 cubic yards to be redistributed, is located between baseline stations 1252+76 and 1282+85 along the east end of the shoreline adjustment area outside the direct influence of the ebb tidal delta. The ebb tidal delta material will immediately begin to migrate onshore following the construction of the sand dike with most of the 1.5 million cubic yards of ebb tidal delta material expected to deposit in the seaward portion of the existing channel during the first 2 years following channel relocation.

The erosion of the 565,000 cubic yards of material situated east of baseline station 1282+85 would be controlled to some extent by longshore sediment transport process, particularly once the abandoned portion of the ebb tidal delta collapses to the point that it no longer significantly impacts wave conditions on the west end of Emerald Isle. Accordingly, an estimate of the amount of time required for the shoreline east of baseline station 1282+85 to adjust was based on sediment transport rates in the area. Estimates of the sediment transport rates applicable to the Emerald Isle shoreline located outside the influence of Bogue Inlet, yielded an average net transport to the west of 272,300 cubic yards/year. With the net sediment transport rate west of station 1252+76 increasing from its present rate of near zero to 272,300 cubic yards/year, the time required to remove the 565,000 cubic yards of material from the shoreline between stations 1252+76 and 1282+85 would be approximately four years. Since most of the longshore movement of the material will not occur until the abandoned portion of the ebb tidal delta undergoes substantial adjustments, the total amount of time for these adjustments to occur will be around six years.

8.5. Shoreline Adjustments on Bear Island. The westward repositioning of the ebb channel and the associated reconfiguration of the ebb tidal delta will have the opposite effect on the Bear Island shoulder. The movement of the ebb delta's apex farther to the west will lead to a seaward movement of the ebb delta's western segment outer margin (zone of breaking waves). This seaward extension of the platform will have a positive influence on the adjacent Bear Island oceanfront by altering the wave refraction patterns and ultimately leading to a reversal of the historic shoreline change trend. Again, based on the amount of shoreline recession that occurred between 1978 and 2001 on Bear Island, various sections of the oceanfront shoreline on Bear Island could accrete by the amounts indicated in Table 8.2:

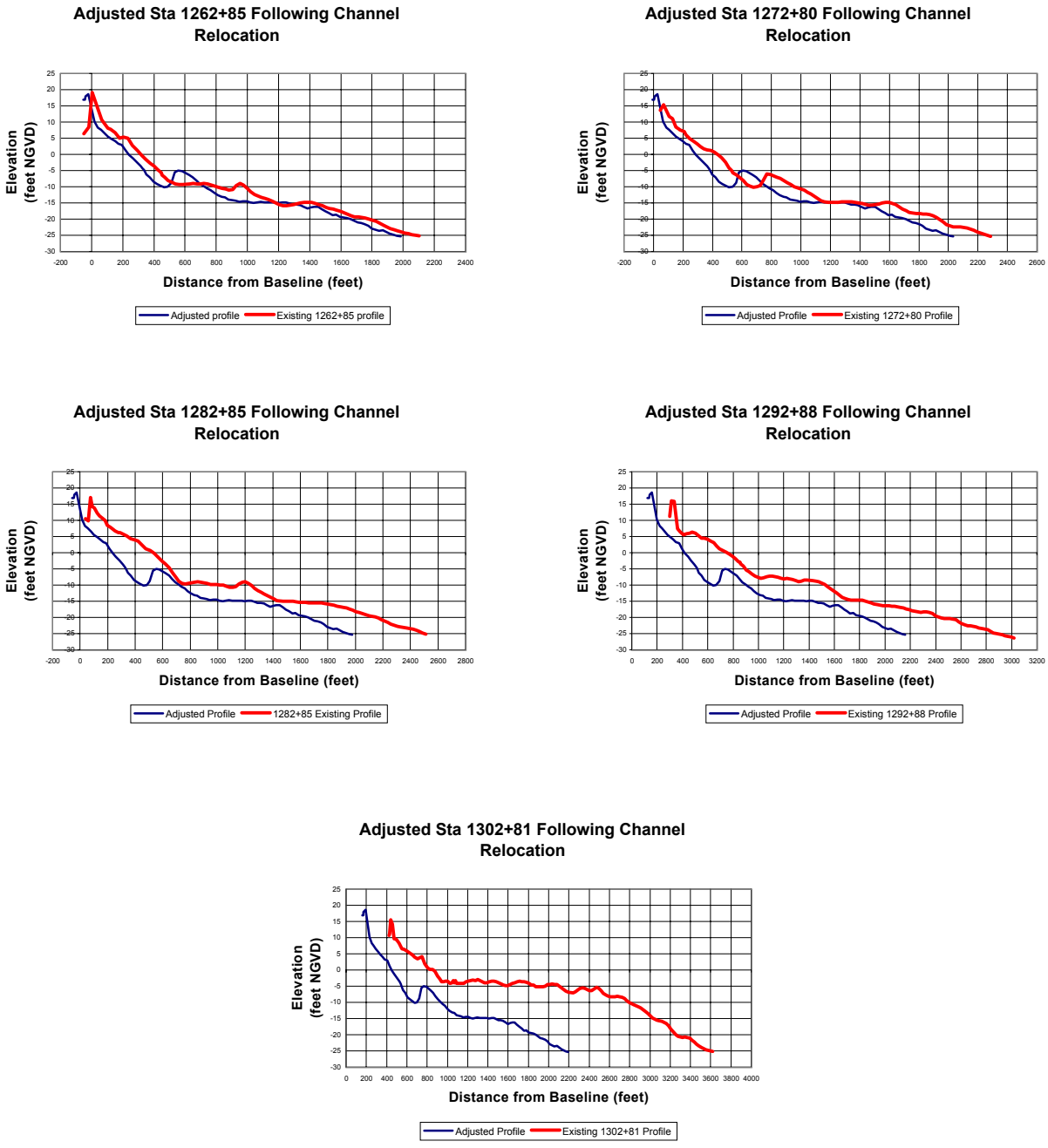

Figure 8.3 Predicted Profile Adjustments Following Relocation of the Bogue Inlet Ebb Channel

Table 8.2
Accretion Rates Associated with Bear Island

	Average Accretion[(a)]	Maximum Accretion
Transects 25 to 27	+470 feet	520 feet
Transects 28 to 32	+230 feet	280 feet
Transects 33 to 37	+130 feet	200 feet

[(a)] Average accretions rounded from those presented in Section 4.

The volume of material required to effect these shoreline adjustments on Bear Island would range between 1.5 and 2.0 million cubic yards. The buildup of this volume of material would come directly from the accumulation of littoral sediment presently being transported into Bogue Inlet that would be prevented from doing so once the ebb tidal delta of Bogue Inlet readjusts to the new channel position and alignment. The accretion on Bear Island will be rather slow and could take up to ten years to occur.

Apart from the positive impacts on the ocean shoreline of Bear Island, a relatively wide marginal flood channel is likely to develop that will separate the evolving ebb channel from the Bear Island inlet shoreline. As a consequence, eastward spit growth on the western shoulder of the inlet near Bear Island will be very limited.

The channel relocation project is not expected to have a direct negative impact on the integrity of Island 2. However, the continued westward growth of the estuarine portion of the Bogue Banks spit may eventually lead to the deflection of the ebb channel to a position adjacent to the eastern portion of Island 2. As discussed above, the growth within this area would not resume until the new sand spit accreted beyond the sand dike position. The eventual erosion of this ephemeral island will likely occur with or without channel relocation, and as discussed previously, Island 2 migrated a significant distance to the west between September 2001 and September 2002.

8.6. Sediment Redistribution. The repositioning of the main ebb channel through Bogue Inlet to a more central position between Bogue Banks and Bear Island will result in the redistribution of a rather large volume of sediment either through the direct actions associated with the channel relocation and dike construction or indirectly through sediment transport process driven by tidal currents and wave action. A summary of the sediment redistribution expected to accompany the construction of the 13.5 ft NGVD x 500 ft channel is shown schematically on Figure 8.4. Also shown on Figure 8.4 are the projected shorelines on the east end of Bear Island and the west end of Bogue Banks and a general outline of the reconfigured ebb tidal delta. As discussed in the geomorphic analysis section, the middle ground shoal of Bogue Inlet has apparently been building in elevation as a result of the present delta configuration that allows swash bars to move directly into the area. With the channel located in a more central location, this stored material will be pushed seaward and reshaped by the new wave refraction patterns associated with the repositioned channel. Finally, the predicted accretion on Bear Island will result in the retention of 1.5 to 2.0 million cubic yards of material that would, under existing conditions, have been transported into and retained by the inlet system.

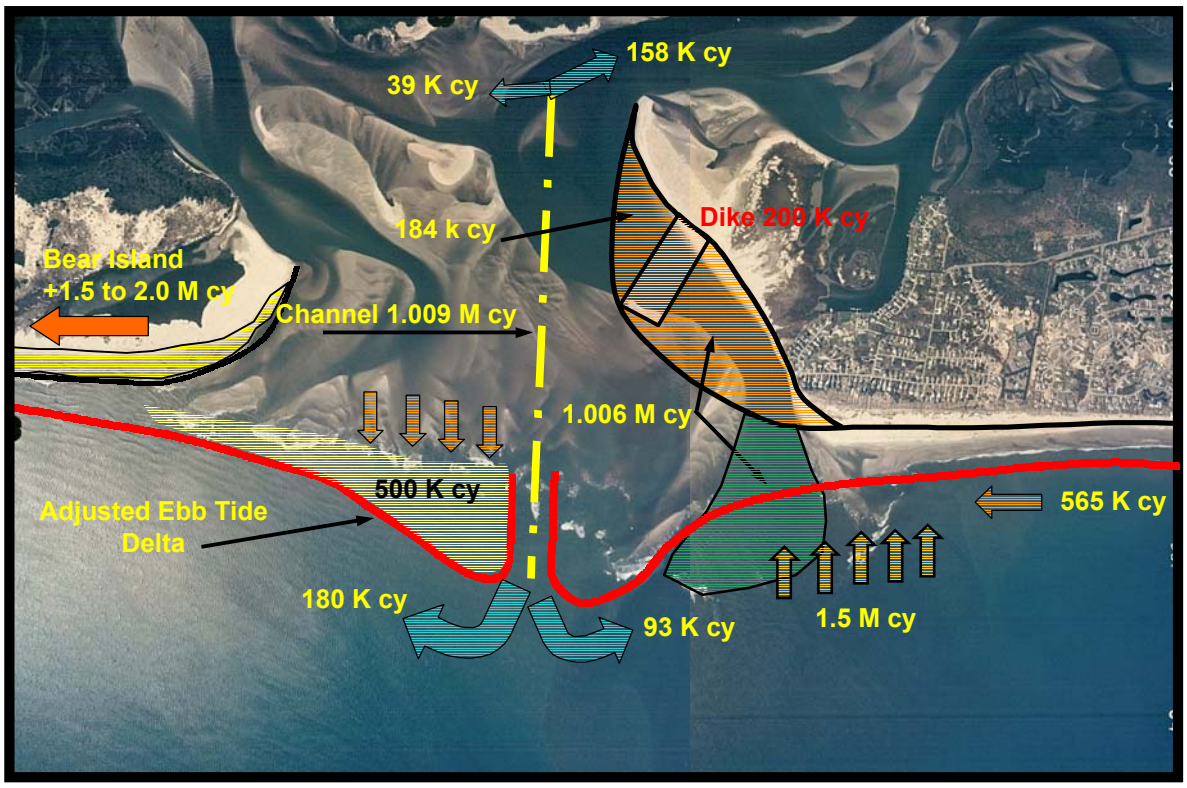

Figure 8.4
Schematic of Sediment Redistribution Following Channel Relocation

9. DESIGN OF CLOSURE DIKE FOR EXISTING CHANNEL: The location of the dike is shown on Figure 9.1 and is in an area where the channel diverges into a predominant flood channel (east side) and ebb channel (west side). Maximum depths in the dike area are around -12 feet NGVD and average approximately -7 feet NGVD. The total distance across the channel, measured from the +4 foot NGVD elevation on both sides of the channel, ranges from 1,650 feet to 1,800 feet. The final crest elevation of the dike will be +4.5 feet NGVD or approximately equal to the maximum elevation of the existing sand spit.

Construction of the dike will be accomplished by pumping material directly into the existing channel from the landward end of the new channel as depicted in Figure 9.1. The pipeline from the dredge to the discharge point would be routed along the existing sand spit with disposal beginning on the east side of the channel and proceeding west across the channel (Figure 9.1). The discharge point of the pipe would be initially placed at an elevation close to mean high water (+2.2 feet NGVD) in order to prevent material from washing back across the sand spit.

The volume of material required to construct the dike was based on a model developed by Creed and Olsen (1999) for a similar channel relocation project located in Port Royal Sound, which borders the northeast shoreline of Hilton Head Island, South Carolina. The simplistic model developed by Creed and Olsen predicted that the dredge would have to pump 160,000 cubic yards into the channel over a period of 3.5 days to close the channel. Peak flow velocities in the channel were comparable to the velocities in the existing Bogue Inlet channel and ranged from around 2 feet per second (fps) during neap tide conditions to 3.3 fps during spring tide conditions. Closure of the channel actually required four days and about 210,000 cubic yards or about 31% more than predicted. Based on the predicted and actual results of the channel closure off Hilton Head, the Creed and Olsen model appears to provide realistic results.

9.1. Model Predictions of Dike Construction. Using the Creed and Olsen model, computations were carried out until the crest elevation of the dike reached an elevation equal 2.5 feet above NGVD or slightly above mean high water. Once the dike reaches this elevation, no flow would occur across the dike and the elevation of the dike could be raised to +4.5 feet NGVD without the interference of the tidal currents. The total construction time determined from the application of the model was 6.5 days with the volume of material required to raise the dike to an elevation of +2.5 ft NGVD equal to 141,200 cubic yards. An additional 8,100 cubic yards would be needed to raise the crest elevation of the dike to +4.5 feet NGVD resulting in a total volume of 148,500 cubic yards. As noted above, the actual volume and time required to close the channel in Port Royal Sound was about 31% greater than predicted. Accordingly, the model results for the Bogue Inlet dike were increased by about 35% resulting in a design volume of 200,000 cubic yards. For the assumed dredge production rate of 900 cubic yards per hour, the total construction time for the dike would be 9.5 days.

9.2. Logistics of the Dike Construction. Closure of the existing channel cannot start until the new channel has been advanced to the point that it begins to carry a significant

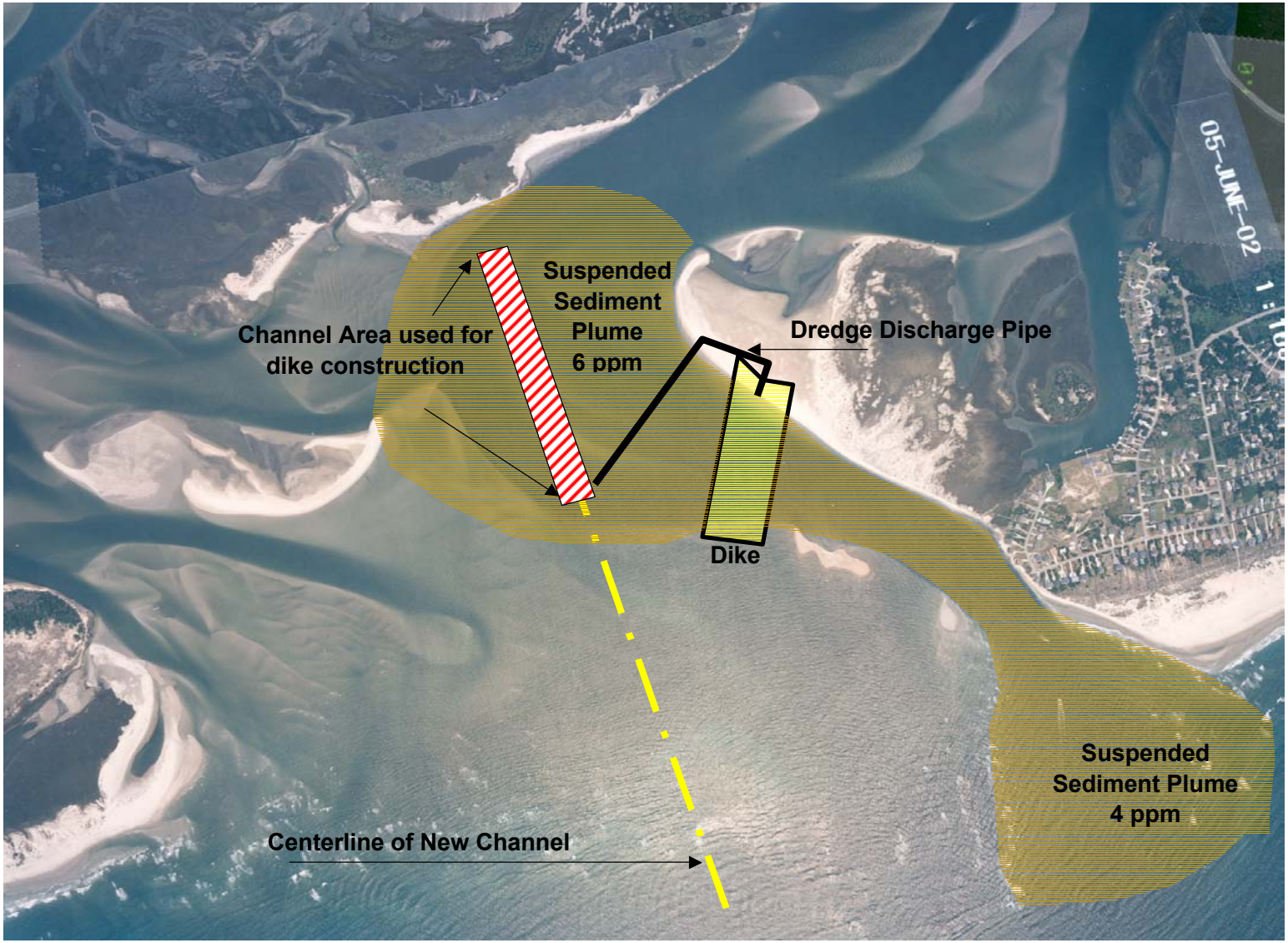

Figure 9.1 Channel Dike Location

portion of the flow through the inlet. The channel centerline station where the volume remaining to be dredge is equal to 200,000 cubic yards is 23+00. The station where pumping into the existing channel would begin is located in the existing ebb channel that swings past Island 2 (Figure 9.1). Therefore, the new channel would be completely open to the sea while the construction of the channel is completed across the shoals located between Island 2 and the Bogue Banks sand spit.

10. ALTERNATIVES TO THE PROPOSED PLAN: In addition to the without project alternative, which is addressed in the following section, alternatives to the channel relocation project considered include:

a. Stabilization of The Pointe Shoreline with a permanent hard structure.
b. Suspension of the COE channel maintenance activities in the existing channel.
c. Channel relocation without beach nourishment.
d. Long-term Inlet Sand Management Strategies.

A brief discussion of each of these alternatives follows.

10.1. Hard Structure. The use of hard structures such as groins, jetties, and/or revetments to protect The Pointe shoreline is not a reasonable or feasible alternative given the State of North Carolina's coastal management regulations that prohibit such structures. Accordingly, details of this alternative were not developed.

10.2. Suspension of COE Channel Maintenance. The COE has been using shallow draft sidecast dredges to maintain the authorized 8-foot mlw by 150-foot wide channel since 1981. During each maintenance operation, the dredging activities are restricted to the deepwater channel that exists at the time of project implementation. As a result, the maintenance dredging is not capable of maintaining a fixed channel alignment and the channel has continually migrated to the east during the maintenance dredging period. If channel maintenance was suspended in the hopes that a new channel would breach through the middle of the interior shoal nothing in the historic record of the inlet's evolution suggests this would occur. A new channel will likely breach through the middle of the inlet at some time in the future with or without maintenance. However, given the immediacy of the erosion problem at The Pointe, waiting for the channel to naturally reposition itself will result in continued erosion and damage to the development and infrastructure at The Pointe. Therefore, suspension of the maintenance dredging activities would not reduce or eliminate the existing erosion threat and is therefore not a reasonable alternative.

10.3. Channel Relocation without Beach Nourishment. In the interest of rapidly reestablishing the lost intertidal habitat that will accompany the repositioning of the inlet channel, consideration was given to stockpiling the dredged material during the channel relocation and transferring the stockpiled material into the existing channel once the channel is completed. This alternative would also include the construction of a sand dike across the existing channel. Areas where the dredged material could be stockpiled include the existing Bogue Banks sand spit and the shoal area located between the new

channel and the existing channel. The available dry land area on the spit totals about 900,000 square feet. Stockpiling 850,000 cubic yards in this area would result in a mound approximately 30 feet high. Stockpiling the material in the shoal area would create some additional problems with material being transported out of the stockpile area by tidal currents. This could possibly be overcome with the construction of a temporary sandbag dike around the stockpile area, but this would add substantially to the cost of the project. The area that could be used to stockpile the material has a surface area of approximately 2,000,000 square feet. Stockpiling 850,000 cubic yards in this area would create a mound approximately 15 feet high. The material could be stockpiled using a combination of the spit area and shoal area, which would reduce the height of the stockpile to about 10 feet.

This alternative would result in substantial damage to the habitat on the existing sand spit and the intertidal shoals, which would offset any accelerated recovery of the intertidal habitat loss as a result of the channel relocation. The amount of intertidal shoal that would be disturbed by the relocation of the channel be 2.8 million square feet (64 acres). Also, the need for beach nourishment material would still exist for the west end of Emerald Isle resulting in the Town of Emerald Isle using the offshore borrow area for this segment of their beach nourishment project. Accordingly, channel relocation without beach nourishment is not a reasonable alternative to the proposed channel relocation/beach nourishment project.

10.4. Inlet Sand Management. The only effective way to permanently control the location of the inlet channel is through a dedicated program of channel maintenance with the material removed from the channel distributed to the adjacent islands. However, the existing 8-foot mlw authorized depth for the inlet channel would not allow ocean certified pipeline dredges (the type of plant necessary to accomplish the work) to routinely maintain the channel given the minimum digging depths of this type of equipment is 12 feet. Increasing the authorized depth in Bogue Inlet would require detailed studies by the COE and Congressional authorization for the channel improvements. The process for obtaining approval for a deeper channel would take several years with the timeline beginning once Congress authorizes the COE to conduct a feasibility study. Such a study has not been authorized nor is authority for such a study being pursued by the COE. Given the immediacy of the erosion threat to development at The Pointe, waiting to gain approval for a deeper channel and associated sediment management is not an option that would address the present needs of the Town of Emerald Isle.

The COE is conducting a feasibility study for long-term storm damage reduction for Bogue Banks and will consider Bogue Inlet as a possible source of beach nourishment material for portions of the Island's shoreline. If the COE elects to use Bogue Inlet as a source of beach nourishment material and concentrates its activities along the channel corridor, the position of the channel could be stabilized. Any consideration of the inlet as a source of beach nourishment material will have to include sand management strategies that will distribute material to both Bogue Banks and Bear Island. The COE is not scheduled to complete the feasibility study for at least two more years with construction

delayed for several more years while final plans are prepared, environmental clearances obtained, and all of the necessary requirements of local cooperation satisfied. Accordingly, the Bogue Banks storm damage reduction project may offer some means to maintain the position of the Bogue Inlet channel in the future but will not be done in time to provide any immediate relief for The Pointe.

11. NO ACTION ALTERNATIVES: Easterly migration of the inlet shoreline began in February 1984 and continues today.

Two alternatives were evaluated for the without project condition. The first alternative (No Action – Alternative No. 1) assumed that the inlet shoreline would continue to migrate at a rate of sixty feet/year to the east over a period of ten years. Under this alternative, a structure would be lost to erosion once the inlet shoreline reaches its foundation. When this occurs, the structure would be abandoned and demolished by its owner. The second alternative (No Action – Alternative No. 2) assumed that sandbag revetments would be constructed to protect buildings and roads once they become threatened. The State of North Carolina considers a structure to be threatened once the erosion encroaches within 20 feet of its foundation. In the case of a road, the threatened status begins when erosion reaches the right-of-way. State rules allow temporary sandbags protecting buildings to remain in place for a period of two years after which they must be removed. Sandbag structures constructed to protect roads are allowed to remain in place for five years after which they must be removed. In practice, the State has granted some extensions of the two year and five year rules, particularly if a long-term protection plan is being formulated. However, for the without project analysis, the assumption was made that no long-term plans are being considered and that the sandbags must be removed at the end of their permit period. Both alternatives assumed that the existing sandbag revetments protecting The Pointe shoreline, which have essentially reached the end of their permit periods, would be removed at the beginning of the analysis.

A third alternative has been suggested that would involve the removal of threatened structures. However, in this situation, the eastward movement of the inlet shoreline not the landward movement of the ocean shoreline is threatening structures. As a result, there is no opportunity to relocate structures farther back on their existing lots. The option of relocating the threatened structures to other lots in The Pointe subdivision is also not available as there are currently only five vacant lots available and these vacant lots will be threatened during the next ten years under existing conditions. Accordingly, the only option would be to remove the buildings from The Pointe subdivision with most structures having to be relocated to sites completely off Bogue Banks. The economic impact on Emerald Isle would be essentially the same for structures removed from the island or lost to erosion; therefore, the abandonment/relocation alternative was not evaluated.

The projected 10-year shoreline position for the 60-foot/year erosion rate is shown on Figure 11.1. The base shoreline used for this projection is shown in red and generally follows the July 2002 vegetation line.

The evaluation of the economic impact of the without project alternatives included damage to real property including cleanup cost once a structure is lost, damage to infrastructure (roads and public utilities), construction of temporary access roads to isolated structures, loss of tax revenues for both the Town of Emerald Isle and Carteret County, and the reduction in household spending associated with the lost homes. In the case of Alternative No. 2, the total cost of providing temporary sandbag structures (construction, maintenance, and removal costs) was also included. Since the Town of Emerald Isle plans to provide beach nourishment along the west end of its shoreline, the cost of nourishing the 20,500 feet of beach using an offshore sand source was added to the economic losses associated with the erosion of the inlet shoreline in order to obtain a full measure of the total economic impact of the without project condition.

Table 11.1 provides a summary of the damages and economic impact to Emerald Isle and Carteret County for Alternative No. 1 in 2-year increments. Table 11.2 includes the estimated $5.8 million for nourishing the west end of Emerald Isle from an offshore sand source.

Table 11.1
Summary of Damages and Impact on Local Economy
No Action - Alternative No. 1
Continued Inlet Shoreline Erosion Over the Next 10 Years

Year	Cumulative Present Worth Damages [(1)]	Cumulative Present Worth Lost Taxes Town & County	Cumulative Present Worth Reduction in Household Spending	Total Present Worth Economic Impact
2	$1,600,400	$20,500	$249,400	$1,870,300
4	$4,617,700	$61,600	$604,100	$5,283,400
6	$6,670,400	$128,100	$1,164,900	$7,963,400
8	$8,804,500	$218,400	$1,884,200	$10,907,100
10	$11,492,800	$337,600	$2,763,100	$14,593,500

[(1)]Includes lost structures, damage to infrastructure, and temporary access roads.

Table 11.2
Total Costs for No Action – Alternative No. 1
Including Offshore Nourishment Cost for the West End of Emerald Isle

Year	Total Present Worth Damages & Economic Impact Plus Offshore Dredging Costs
2	$ 7,670,300
4	$ 11,083,400
6	$ 13,763,400
8	$ 16,707,100
10	$ 20,393,500

Once the existing sandbags are removed from The Pointe shoreline, five structures would immediately fall victim to the inlet shoreline erosion. At the end of the first two years of the analysis, a total of seven structures would be destroyed. Over the ten year analysis period, thirty-six structures would be lost along with all of Bogue Court, Inlet Court, and a considerable portion of Inlet Drive.

Future damages and economic impacts to Emerald Isle and Carteret County for Alternative No. 2 are summarized in Table 11.3 with the total economic impact, including beach nourishment from an offshore sand source, provided in Table 11.4.

Table 11.3
Summary of Damages and Impact on Local Economy
Without Project Condition - Alternative No. 2
Temporary Sandbags

Year	Cumulative Present Worth Damages [1]	Cumulative Present Worth Lost Taxes Town & County	Cumulative Present Worth Reduction in Household Spending	Total Present Worth Economic Impact
2	$1,099,900	$16,800	$208,000	$1,324,700
4	$2,101,500	$34,300	$426,000	$2,561,800
6	$3,992,600	$66,300	$726,000	$4,784,900
8	$6,218,500	$113,100	$1,178,100	$7,509,700
10	$8,134,900	$183,500	$1,859,400	$10,177,800

[1] Includes lost structures, damage to infrastructure, temporary access roads and costs associated with sandbags.

Table 11.4
Total Costs for Without Project Condition – Alternative No. 2
Including Offshore Nourishment Cost for the West End of Emerald Isle

Year	Total Present Worth Damages & Economic Impact Plus Offshore Dredging Costs
2	$7,124,700
4	$8,361,800
6	$10,584,900
8	$13,309,700
10	$15,977,800

The number of structures that would be lost following the removal of the existing sandbag revetments protecting The Pointe shoreline would be five under Alternative No. 2, however, sandbags would protect other threatened structures during the first two years following the removal of the existing sandbags so that no additional structures would be lost during the first two years. Since the sandbags protecting structures can only remain in place for two years, by the fourth year of the analysis, a total of nine structures would still be lost. Sandbag revetments constructed to protect threatened sections of Bogue Court and Inlet Drive would remain in place for five years and would prevent any damage to the roads and infrastructure during the first four years under the sandbag alternative. By the end of the ten year analysis period, the total number of structures lost to the inlet shoreline erosion would be twenty-nine with the majority of these losses occurring between years six and ten.

The cost of the Bogue Inlet Channel Relocation project will likely be between $5 and $6 million. Therefore, the project is economically justified even if the inlet shoreline only erodes another two years.

12. ENVIRONMENTAL STUDIES AND COORDINATION: The Draft EIS will consider potential direct, secondary and cumulative effects on Essential Fish Habitat (EFH), nesting and foraging habitat for shorebirds, intertidal and subtidal infauna/macrofauna, endangered and protected species, adjacent shorelines and estuarine habitat, water quality, socio-economic resources, cultural resources, health and safety, and other impacts identified through scoping, public involvement and interagency coordination. The scoping process involves Federal, State, County, and municipal agencies and other interested organizations and individuals. An official public scoping meeting was-held on October 29, 2002. The proposed action is being coordinated with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service under Section 7 of the Endangered Species Act, the Fish and Wildlife Coordination Act, and the

Magnuson-Stevens Fishery Conservation and Management Act; and with the North Carolina Division of Coastal Management under the North Carolina State Environmental Policy Act (SEPA).

The Town of Emerald Isle held a public, interagency meeting on May 29, 2002 to hear preliminary resource protection agency concerns regarding the proposed action. Federal and State agencies provided written comments that were addressed during development of the alternatives analysis and biological monitoring plan. The biological monitoring plans were coordinated and reviewed by the resource protection agencies to ensure that all ecological and biological concerns have been addressed. Potential impacts to significant marine, estuarine and beach/dune resources will be evaluated from the perspectives of avoidance, minimization, and mitigation.

The proposed project will be constructed between November 16th and March 31st to limit construction activities to the period outside the critical life stages of birds and fish, sea turtle nesting and hatching season, the migratory passage of marine mammals, and the flowering stages of plants.

13. **OVERVIEW OF RESOURCE PROTECTION AGENCY CONCERNS:** Biological resource concerns for the channel relocation efforts have been presented by several interested parties including the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the North Carolina Division of Water Quality, the North Carolina Natural Heritage Program, and the North Carolina Department of Environment and Natural Resources (including the Division of Coastal Management, Division of Marine Fisheries and the Wildlife Resource Commission). These concerns include impacts to benthic organisms during dredging operations; temporary increase in turbidity affecting Essential Fish Habitat, salt marsh, shellfish habitat and Submerged Aquatic Vegetation communities; direct and secondary impacts to nesting and foraging habitat for piping plovers, least terns, black skimmers, other shorebirds and waterbirds; concerns of adjacent islands erosion (i.e., Bear Island**,** Island Number 2) and interior marsh islands (primarily Dudley Island); intertidal and subtidal macroinfauna impacts from inlet closure and new channel creation; changes in salinity, temperature and turbidity levels in adjacent rivers and estuarine habitats; potential for increased sedimentation in Cow Channel; and alteration of migration patterns of marine mammals and sea turtles.

14. **BIOLOGICAL MONITORING PLAN:** Biological monitoring efforts have been designed to provide information regarding the utilization and habitat significance for listed, protected, and managed fish and wildlife species within the proposed project area. Due to concerns over indirect effects to Huggins and Dudley Islands, West End Beach, Bear Island, Island Number 2, areas of Bogue Sound, Hawkins Island, Jones Island, and Cedar Point Marshes in the White Oak River; these areas were considered for inclusion. Existing monitoring data for the Bogue Inlet study area is being evaluated and utilized, where appropriate, as a historical baseline. Essential Fish Habitat, Habitat Areas of Particular Concern and Critical Habitat for Wintering Piping Plover, as well as habitat for

listed and protected species such as sea turtles and seabeach amaranth, have also been identified within the study area.

The North Carolina Wildlife Resource Commission (NCWRC) maintains the most complete database on the piping plover population in North Carolina. Historical nesting and over wintering data is being evaluated to provide a baseline for impact evaluation. Additional pre- and post-construction monitoring was deemed necessary due to insufficiency of the existing data set and to provide accurate representation of the bird species utilizing the project area. All other colonial waterbirds and shorebirds will also be surveyed in conjunction with the piping plover surveys.

Approximately 14 square miles of land and water resources in and around Bogue Inlet will be extensively surveyed through the used of aerial photography, topographic/bathymetric surveying and habitat mapping to provide accurate pre-construction baseline data. Methods of avoidance and minimization of proposed project affects on shellfish, Submerged Aquatic Vegetation (SAV), fish populations, migratory shorebird nesting and foraging habitat, and sea turtle nesting habitat will be identified during the plan formulation analysis.

Three biological monitoring plans were developed for the project and designed to provide current baseline data upon which potential effects to sensitive resources within the project area can be evaluated. Pre-construction biological monitoring of the project area began in April 2003 and will continue until April 2004. A minimum of three-years post-construction monitoring is expected to be required by State and Federal resource protection agencies to evaluate project effects. Monitoring and sampling efforts within the study area include benthic macroinfauna sampling; piping plover, other shorebirds, and colonial waterbird monitoring; sea turtle nesting and hatching; and salt marsh community and sedimentation monitoring. Water quality sampling of turbidity will be conducted during construction to ensure that the project is in compliance the requirements of the North Carolina Department of Environmental Water Quality.

The biological monitoring plans were submitted to the Army Corps of Engineers on November 21, 2002 were also and distributed to members of the Project Delivery Team (PDT). The monitoring protocols, methods and schedules were reviewed and have been modified to address concerns presented by the COE, the North Carolina Wildlife Resource Commission, the North Carolina Division of Water Quality, USFWS, NMFS, and other members of the PDT.

A summary of the biological monitoring efforts is provided below. Refer to Figure 14.1 for a graphical representation of the biological monitoring efforts being conducted in the project area.

14.1 Bird Monitoring

Bird monitoring for the project is being conducted along four transect areas: Transect Area No. 1 begins along the northern edge of the west end of Bogue Banks, following the shoreline south to a location near The Pointe Subdivision; Transect No. 2 encompasses

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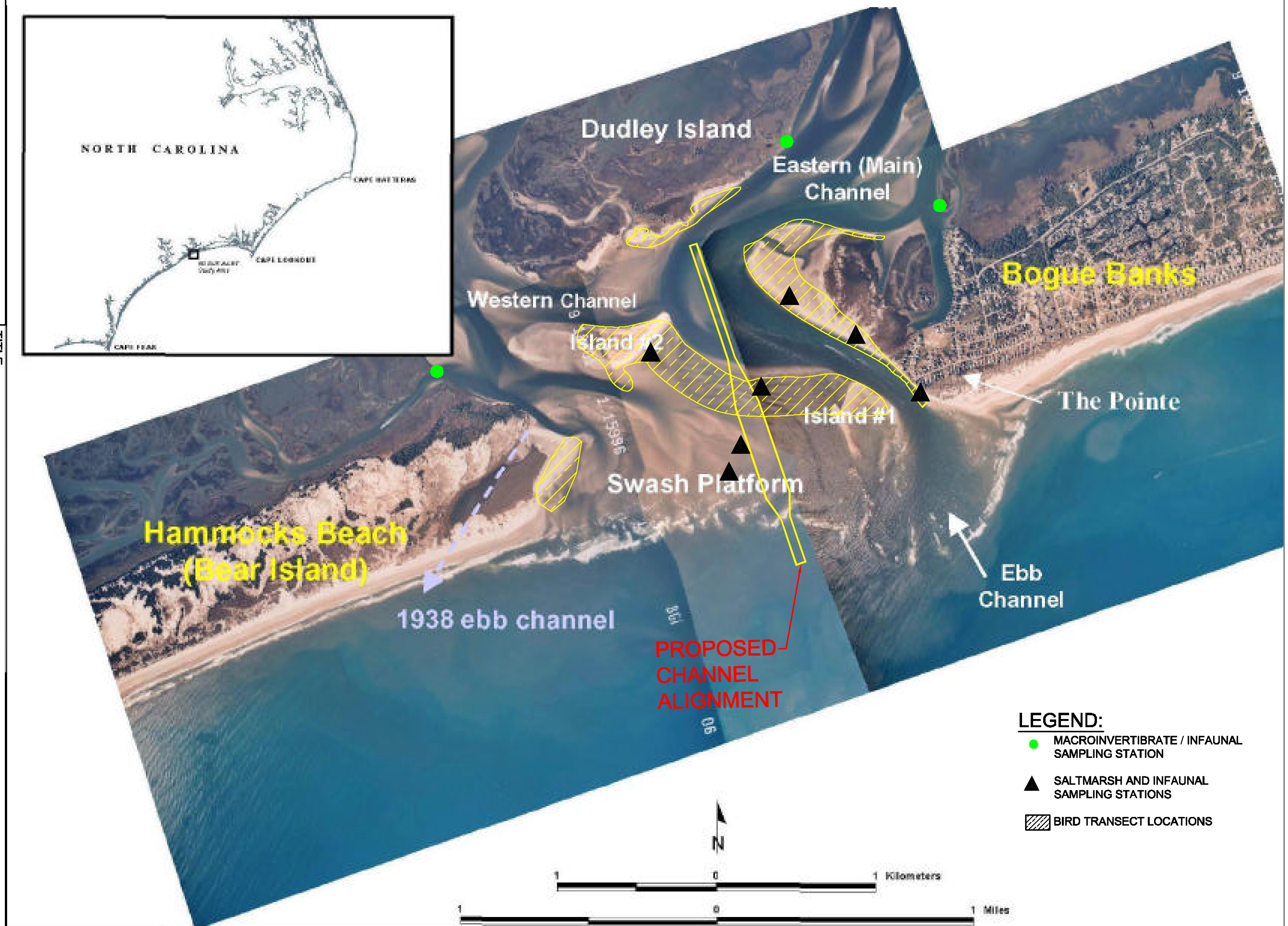

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TITLE:

BIOLOGICAL MONITORING STATIONS

DATE: 7/5/03

BY: EAH

COMM. NO.: 4500.03

FIGURE NO. 14.1

Island No. 2 and a portion of the eastern perimeter of the mid-inlet shoal; Transect Area No. 3 encompasses the potential project impact area along the south side of Dudley Island; and Transect No. 4 extends along the eastern side of Bear Island proceeding west for 500 meters along the ocean shoreline (Figure 14.1). Monitoring areas include accreting areas along the inlet; bayside, sand and mud flats; and recently disturbed areas such as wash overs. Bird monitoring observations are conducted by an ornithologist equipped with a spotting scope to assist in identifying nesting, roosting, and foraging activities, as well as territory establishment, courtship, and copulating birds.

Monitoring of bird species began on April 2, 2003 and will continue for one-year during the breeding, migratory and wintering periods to obtain baseline information. Surveys are conducted approximately every ten days during the spring migration (March 1st to April 30th); approximately every fifteen days during the breeding season (May 1st to July 13th); and approximately every ten days during the fall migration (July 14th to November 30th). Bird monitoring surveys return to a monthly schedule from December 2003 thru February 2004.

Monthly reports of observations made along the four transect areas are submitted to the COE, USFWS, NCWRC, as well as other concerned parties. A pre-construction monitoring report summarizing data will be prepared and submitted at the end of the monitoring period. Post-construction reports will be prepared and submitted on May 30th of every year and will document observations through April 1st of the reporting year.

14.2 Macroinvertebrate and Infaunal Sampling

Macroinvertebrate and infaunal sampling will occur at three locations along the existing channel and along the proposed channel alignment to provide a representation of the species common to the project area (Figure 14.1). Sampling parameters include coquina clams (*Donax variabilis*), mole crabs (*Emerita talpoida*), penaeid shrimp (*Penaeus* sp.), and amphipod and polychaete indicator species. Six sampling stations are located along the existing channel (Stations 1-3) and adjacent to the new channel alignment (Stations 4-6). One sampling site (Station 7) is located in the intertidal habitat on the south side of Island No. 2. This sampling station has been included as a reference site for the infaunal samples located along the existing and proposed channel alignment.

Three additional infaunal sampling stations are located and coincide with the salt marsh monitoring stations to identify benthic species in the substrate of the salt marsh communities. Continuous sampling at these locations will provide insight into the potential for change in species diversity and abundance due to erosion or accretion in the vicinity of the salt marshes.

Infaunal data for each station will be reported as the number of individuals from each taxon, the number of species and the total number of organisms per square meter. Annual reports documenting the findings will be prepared simultaneously with the saltmarsh monitoring report. A pre-construction monitoring report will be submitted to the COE, at the end of the study period. Post-construction infauna monitoring reports will be submitted at the end of February of each year.

14.3 Salt Marsh Monitoring

Salt marsh vegetation has been used as a reliable indicator of salinity levels and hydrologic conditions in estuarine environments. Monitoring of salt marsh habitats in the project area was designed to assess and document the potential effects of project implementation, such as sedimentation accumulation, on adjacent salt marshes. Salt marsh monitoring transects are located at the following stations: 1) north of Bogue Inlet on the east side of the main channel, 2) on the east side of Dudley Island, and 3) north of Bear Island. A total of four monitoring events will be conducted to determine if impacts are directly or indirectly attributed to project activities.

The project effects on vegetative conditions will be most pronounced during active vegetative growth and development periods. Therefore, observations of these effects will be better identified at the end of the growing season in September/October. Pre-construction monitoring to collect baseline conditions will be conducted at the end of the growing season in either September or October 2003. Annual saltmarsh monitoring will continue for three-years post-construction in September/October of each year.

Appendix 1 provides the approved Bird, Macroinvertebrate/Infaunal and Salt Marsh Monitoring Plans for the Bogue Inlet Channel Relocation project.

The biological monitoring data will be used in conjunction with the mapping and water quality data to assist in evaluating changes in salinity and the hydrologic flow regime upstream of the inlet.

15. PROJECT IMPACT SUMMARY

Listed below are the major events and associated changes expected to occur within the project area from the westward repositioning of the ebb channel (selected alternative):

- Migration of the middle ground shoal (located west of the existing channel) to form the ebb tidal delta of the new channel;
- Accretion along the ocean shoreline of Bear Island;
- West end of Bogue Banks;
  - onshore movement of ebb tidal delta at the west end of Bogue Banks
  - transport and deposition of sediment along the inlet shoreline of Bogue Banks
  - development of sand spit from the west end towards Bogue Inlet
  - infilling of abandoned (existing) channel west of The Pointe shoreline
- Island 2 is an ephemeral island that is expected to migrate with or without project implementation and sand dike installation;
- Easterly transport effects along Emerald Isle will limit overall net sediment transport along the ocean shoreline of Emerald Isle;
- Beach nourishment of 20,500 feet (3.9 miles) of Phase 3 of the Emerald Isle project area;
- 39,000 cy of sediment transport in the southern portion of the Western Channel; and

- 158,000 cy of sediment transport deposition in the southern portion of the eastern channel over eastern channel area of Bogue Inlet.

These predicted changes are based on the geomorphic analysis, numerical modeling and effects observed after channel relocation project.

16. LISTED SPECIES AND CRITICAL HABITAT THAT MAY BE AFFECTED: Table 16.1 provides a list of federally protected species that may be found in the various habitats surrounding the project area. However, the presence and abundance of the species strongly depends on the availability of the appropriate habitat.

Table 16.1
Federally Listed Threatened and Endangered Species Identified or Expected to Occur in the Vicinity of Bogue Inlet, Carteret and Onlsow Counties.

Common Name	Scientific Name	Status
Loggerhead Sea Turtle	*Caretta caretta*	Threatened
Green Sea Turtle	*Chelonia mydas*	Threatened
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered
Hawksbill Turtle	*Eretmochelys imbricata*	Endangered
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Endangered
West Indian Manatee	*Trichechus manatus*	Endangered
Humpback Whale	*Megaptera novaeangliae*	Endangered
Right Whale	*Eubalena glacialis*	Endangered
Shortnose Sturgeon	*Acipenser brevirostrum*	Endangered
Piping Plover	*Charadrius melodus*	Threatened
Roseate Tern	*Sterna dougallii*	Endangered
Seabeach Amaranth	*Amaranthus pumilus*	Threatened

Key: Status — Definition
Endangered - A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened - A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

Source: USFWS, http://nc-es.fws.gov/es/countyfr.html. Updated 2/05/2003.

Critical Habitat for Wintering Piping Plover (*Charadrius melodus*) has been identified by the USFWS along the west end of Bogue Banks. The sand shoal islands adjacent to Bogue Inlet, and the eastern tip of Bear Island are included in the area designated as Critical Habitat for Wintering Piping Plovers. Minimization and mitigation measures, presented earlier, are designed to protect or replace this critical habitat and will be included in the final design of the project. The habitat mapping, aerial photography, and topographic/bathymetric surveying of the project area to be conducted during the summer of 2003, will assist in the development of mitigation measures necessary to protect this habitat. Refer to Section 17.6.2 for measures associated with Critical Habitat protection for Wintering Piping Plover.

Federal listed species of special concern such as the black rail (*Laterallus jamaicensis*), dune bluecurls (*Trichostema* sp. 1) and the undescribed skipper (*Atrytonopsis* sp. 1) may also be found within the project area.

The black rail frequents the coastal salt marshes of North Carolina during breeding season. However, it is known to winter in South Florida, and therefore is not expected to be present during construction activities (Canada's Aquatic Environments, University of Guelph, 2002). Observations of this species in the project area will be documented during the bird monitoring surveys.

Dune bluecurls is a plant that occurs on the vegetated secondary dunes in North Carolina. The project will introduce new sediments to the littoral profile seaward of the base of the existing dune systems and escarpments, and therefore is not expected to adversely impact dune or terrestrial resources or species of special concern.

An unnamed skipper (butterfly) was recently discovered on Brandt and Radio Islands at the eastern end of Bogue Sound. Genetic studies of the species are currently underway to determine if the skipper is endemic to this area or a previously known species. The habitat requirements for the skipper are unknown and are currently under investigation. (USFWS Bogue Banks Draft CAR, 2002)

Other Federally listed rare, threatened, or endangered species in Carteret and/or Onslow County not found in the coastal environments are: eastern cougar (*Puma concolor couguar*), American alligator (*Alligator mississippiensis*), bald eagle (*Haliaeetus leucocephalus*), red cockaded woodpecker (*Picoides borealis*), rough-leaved loosestrife (*Lysimachia asperulaefolia*), and Cooley's meadowrue (*Thalictrum cooleyi*). Since these species are not likely to be found at this project site, they are not expected to be affected by the proposed work.

17. SPECIES ASSESSMENTS:

17.1 LOGGERHEAD TURTLES, GREEN, LEATHERBACK, HAWKSBILL, AND KEMP'S RIDLEY SEA TURTLES

17.1.1 Status and Natural History of Species in Project Area

The North Carolina Wildlife Resource Commission has the most complete list of sea turtle nesting data (1997-2002) collected for Bogue Banks and Bear Island. Daily surveys of the area are conducted by the NCWRC and trained volunteers beginning on May 1st and continue until September 1st of each year or until the last documented nest hatches. Data provided by the NCWRC indicates that all but two of the nests identified in the survey area during the study period were loggerhead sea turtles (*Caretta caretta*). The other two nests were from green sea turtles (*Chelonia mydas*).

Loggerhead sea turtles are most commonly found nesting from Bogue Inlet to Beaufort Inlet between March and October. Loggerheads are known to frequently use North Carolina coastal waters as migration corridors (Wynne, 1999). Loggerhead nesting data

from 1997 through 2002 range from eleven to thirty-five nests along Bogue Banks (not including Fort Macon) and from eight to forty-five along Bear Island (Godfrey, 2003).

Green sea turtles can be found nesting from May to November along the beaches east and west of Bogue Inlet (Matthew Godfrey, personal communication, 2002), and are generally found in shallow water environments, such as nearshore reefs, bays and inlets. The turtles are attracted to shallow lagoons with a algal and marine seagrasses communities (USFWS, 2003). The NCWRC reported two green turtle nests on Bogue Banks in May and June 2000.

The leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*) sea turtles prefer deep, saltwater environments and are uncommon in the vicinity of Bogue Sound. The Kemp's ridley (*Lepidochelys kempii*) turtles have been known to nest in the Gulf of Mexico, but can be found foraging in the shallow water environments of North Carolina. Leatherback and hawksbills have only been found to nest in the State of Florida and are not common in North Carolina (USFWS, 2003), although leatherbacks have been observed migrating in the vicinity of Bogue Inlet from May to June (Matthew Godfrey, personal communication, 2002).

Historical information on the leatherback, hawksbill, and Kemp's ridley sea turtles in the vicinity of Bogue Inlet is scarce and there are no records available on the leatherback sea turtle presence or absence on the east end of Bear Island, the south end of Dudley Island or the west end of Emerald Isle (Matthew Godfrey, personal communication, 2003). Anecdotal reports of one or two strandings of hawksbill turtle in the southern region of the North Carolina coast (e.g., Sunset, Holden, and Caswell Beaches) have been reported as well as several strandings of the Kemp's ridley sea turtles in the vicinity of Bogue Inlet (Matthew Godfrey, personal communication). It should be noted that researchers agree that strandings are not an indication of sea turtle distribution and occurrence, and therefore cannot be used for sea turtle abundance indices.

The diamondback terrapin (*Malaclemys terrapin*) is a Federally listed species of concern known to exclusively inhabit brackish waters from Cape Cod, Massachusetts to Corpus Christi Bay, Texas. These turtles commonly inhabit salt marshes, tidal flats, impoundments, and sounds behind barrier islands. The subspecies Carolina diamond-back terrapin (*M. t. centrata*) is a North Carolina listed species of special concern that can be found in salt or brackish marshes and estuaries in the vicinity of Bogue Inlet. During the winter months, they are known to hibernate in muddy burrows along tidal creeks and ponds. Primary feeding grounds for this species are subtidal mud flats and shallow tidal creeks. (South Carolina Department of Natural Resources, 2001). The State of North Carolina does not have records or observations of the Carolina diamondback terrapin, but the State of South Carolina has studied these turtles extensively (Matthew Godfrey, personal communication, 2003).

17.1.2 Effect Determination

Several measures have been proposed in the design of this project to reduce the potential for adverse impacts to sea turtles. These measures include: 1) construction timing to

occur between November 16th and March 31st outside of nesting and migration season; 2) use of a cutter suction pipeline dredge; and 3) presence of a biological observer to monitor protected species during dredge and fill operations.

The project is not likely to adversely affect the hawksbill and leatherback sea turtles since these species are rarely observed or found nesting along the Atlantic coast of North Carolina. The most complete database, along Bogue Banks and Bear Island provided by the NCWRC, for the six year period from 1997 to 2002 shows no indication of the hawksbill or leatherback sea turtles in the project area.

Loggerheads, green turtles, and Kemp's Ridley sea turtles have been reported as the most common sea turtles nesting and foraging in the vicinity of Bogue Inlet (Matthew Godfrey, personal communication, 2002). The proposed project is likely to adversely affect the loggerhead, green sea turtles, and Kemp's Ridley sea turtles during beach nourishment efforts. Dredge and fill areas will be closely monitored and a construction methodology will be developed to limit adverse impacts to these species.

Although once considered a delicacy in the early 1920's resulting in devastating losses, the diamondback terrapin and the Carolina diamondback terrapin is now most severely threatened by estuarine habitat loss. Since the proposed project has the potential to indirectly affect the estuarine habitats behind Bogue Inlet, the project is likely to adversely affect these sea turtles although their presence has not been documented in the project area.

17.2. WEST INDIAN MANATEE

17.2.1 Status and Natural History of Species in Project Area

The West Indian manatee (*Trichechus manatus*) may be found from Bogue Inlet to the upstream estuarine, brackish, and freshwater environments of the White Oak River. Manatees have been recorded in North Carolina waters nine months of the year, but are most likely to occur from June through October (Schwartz, 1995). Manatees can be found in waters as shallow as 5 feet to as deep as 20 feet (USFWS, 2003).

17.2.2 Effect Determination

The proposed work will occur between November 16, 2004 and March 31, 2005, during the time of year when manatee occurrence in North Carolina is at its lowest, therefore the project is not likely to adversely affect this species. However, precautionary measures will be taken during construction activities to ensure that this species in not affected during project construction. Precautionary measures may include: 1) construction personnel instruction on the appearance, movement characteristics, and criminal penalties associated with harming manatees; 2) performance of visual surveys within the 300 feet of the work zone during construction activities to ensure that this species is not present; 4) if manatees are identified within the 300 feet of construction, precautionary measures will be implemented to avoid the species; 5) all construction equipment will be shutdown if manatees are identified within 100 feet of the construction equipment; 6) construction activities will resume once the manatee(s) have left the work zone; and 7) construction

will cease and the USFWS and NCWRC will be notified immediately if a construction related collision or injury to a manatee occurs.

The attached Precautionary Guidelines for General Construction in Areas Which May Be Used by the West Indian Manatee in North Carolina Appendix 2 will be included in the Construction Bid Document and project specifications to avoid and minimize potential impacts to manatees.

17.3. HUMPBACK WHALES AND RIGHT WHALES

17.3.1 Status and Natural History of Species in Project Area

Humpback whales (*Megaptera novaeangliae*) are found in protected waters over shallow bars and shelf waters used by the species for breeding and feeding. Humpbacks migrate towards the poles in the summer and toward the tropics in the winter and are known to be present in North Carolina coastal waters during the seasonal migration, especially between the months of December and April (Conant, 1993).

The right whale (*Eubalena glacialis*) usually winters in the waters off the coast of Georgia and Florida, but has been occasionally sighted off the coast of North Carolina. Similar to the humpback whale, right whales are more commonly found in deep water, but will venture within a few hundred meters of the shoreline (Schmidly, 1981).

17.3.2 Effect Determination

Indirect adverse affects to these species may occur due to the disturbance to their food source (e.g., plankton and krill). However, disturbance of potential food source populations by dredging activities and burial associated with the Bogue Inlet Channel Relocation project will be limited to the immediate project area. Based on studies conducted during similar projects, effects to food sources will be short-term and populations are expected to quickly re-establish through natural recruitment from adjacent, unaffected areas. A whale observer with whale identification experience will be present during dredging and filling operations, if required by State and Federal resource protection agencies. Direct impacts such as collisions with the whales are not anticipated. Considering that the construction work will occur in shallow tidal environments, the work is not likely to be in areas where Humpback Right or other whale species frequent and is therefore not likely to adversely affect the whale species.

17.4 SHORTNOSE STURGEON

17.4.1 Status and Natural History of Species in Project Area

The shortnose sturgeon (*Acipenser brevirostrum*) can be found along the Atlantic seaboard from the southern reach of Canada to as far south as Florida. The sturgeon is typically found in the lower reaches of large rivers and coastal waters. Sturgeon have been shown to spend most of the year in brackish or salt water and move into fresh water only to spawn (USFWS, 2003). Shortnose sturgeons have been documented in the vicinity of Bogue Inlet (Onslow County) within the last 20 years (USFWS, 2003).

17.4.2 Effect Determination

Project construction and maintenance may adversely affect this species. Some of its invertebrate food sources may also be affected, however, similar to the whale species, impacts to food sources will be temporary in nature and natural recruitment will quickly reestablish the potential food source populations. The NMFS, in correspondence dated March 3, 2003, stated that the shortnose sturgeon is typically found in large rivers near the Cape Fear area and the NMFS has determined that the proposed project is not likely to adversely affect this species.

17.5 PIPING PLOVER

17.5.1 Status and Natural History of Species in Project Area

The piping plover (*Charadrius melodus*) is known to be present in the Bogue Inlet area throughout the year and utilize the region for nesting, overwintering, and migration. Plovers have been documented arriving at their breeding grounds from late March to April. By early September both adults and young generally depart for other wintering areas. Piping plovers prefer coastal environments during the winter, especially areas with expansive sand or mudflats for feeding that are located close to a sandy beach used for roosting. As part of the USFWS, the North Carolina Natural Heritage Program has recorded the piping plover in both Carteret and Onslow Counties.

The North Carolina Wildlife Resource Commission has collected piping plover data at Bogue Inlet since 1985. The NCWRC has not sighted a breeding pair of piping plovers in the Bogue Inlet area, although the NCWRC has noted that suitable habitat exists to support breeding activity (Sue Cameron, personal communication).

The NCWRC has identified the sand shoals of Bogue Inlet as good foraging and loafing habitat for piping plovers, other shorebirds and colonial waterbirds during migration and wintering. The NCWRC has also found that the beaches of Bogue Inlet provide habitat for migratory and wintering shorebirds and colonial waterbirds.

The gull-billed tern (*Sterna nilotica*) is recognized as a state-listed threatened species under the North Carolina Natural Heritage Program (LeGrand, 2001). This species has historically been found to nest around Bogue Inlet (Sue Cameron, personal communication). Gull-billed terns nest on barrier beaches, natural islands or shoals and dredged material islands. Gull-billed terns are reported to arrive in North Carolina between mid-April and early May, with nestings occurring in mid-May (Parnell et al., 1993). A gull-billed tern was observed resting on Bear Island on April 22, 2003 by CZR, Inc.

Other shorebirds including Wilson's plovers (*Charadrius wilsonia*), American oystercatchers (*Haematopus palliatus*) and willets (*Catotrophorus semipalmatus*) have been observed breeding in the areas adjacent to Bogue Inlet. Colonial waterbirds with documented breeding activity adjacent to Bogue Inlet include black skimmers (*Rynchops niger*), common terns and least terns (*Sterna antillarum*).

17.5.2 Effect Determination

The west end of Emerald Isle and Bear Island has been documented as habitat for piping plover, other shorebirds and colonial waterbirds (Sue Cameron, personal communication). The proposed work will be conducted during the winter season (November 16, 2004 through March 31, 2005) when migration is at its lowest.

Several measures will be implemented to avoid disturbing piping plover species and its habitat. Because the work along the shoals of Bogue Inlet will be timed outside of piping plover nesting season and the plovers are mobile, adverse impacts are not likely to occur. The project may cause some erosion to the distal end of the present sand spit extending from the west end of Emerald Isle. The loss of this site will be replaced by the formation of a new spit east of the new inlet channel.

Monitoring of piping plovers and other species of special concern identified under the North Carolina Natural Heritage Program will be conducted before, and after construction to evaluate affects. Additional mitigation and minimization measures indicated in Section 19 may be implemented to limit the potential for impacts to the listed bird species and their habitat.

A cutter suction dredge will be used to access the new dredge location from the ocean side of Bogue Inlet. The dredge will cut through clean, sorted sand before depositing the sediment onto the beaches of Emerald Isle and into the existing main ebb channel of Emerald Isle. Dredging operations are not expected to adversely impact the piping plovers because of the slow mobility of the equipment which, allows the birds to relocate as the dredge approaches. The vibration and noise associated with the dredge will alert the piping plovers as construction activities near their location.

17.6 CRITICAL HABITAT FOR WINTERING PIPING PLOVER

17.6.1. Status and Natural History

On July 10, 2002, the USFWS designated 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas as critical habitat for wintering piping plover (*Charadrius melodus*) (Department of Interior-Fish and Wildlife Service, 2001). The Endangered Species Act of 1973 considers piping plover a threatened species when on their wintering grounds. Piping plovers begin arriving on their wintering grounds in July, with some arriving as late as early September, possibly due to a late nesting period. Piping plovers can be found in their in their wintering grounds throughout the year.

The primary constituent elements found to be essential for the conservation of wintering piping plovers are habitats that support foraging, roosting, and sheltering, or have the capacity to develop those components. These primary constituent elements are found in geologically dynamic coastal areas such as migrating inlets that can support or have the potential to support intertidal beaches, mud flats, sand flats above the annual high tide line, and associated dune systems. Essential components of intertidal flats include sand and/or mud flats for feeding with no or very sparse emergent vegetation located near a

sandy beach that can be used for roosting (USFWS, 2003). These areas have been identified as preferred wintering areas.

Critical Habitat for Wintering Piping Plover in Bogue Inlet (Figure 17.1) is listed as Conservation Unit NC-10 of the Federal Register (50 CFR Part 17). This unit is described as the "contiguous land south, west and north of Bogue Court to the MLLW line of Bogue Inlet on the western end of Bogue Banks. It includes the sandy shoals north and adjacent to Bogue Banks and the land on the Atlantic Ocean side. This unit also extends 1.3 km (0.8 miles) west of Bogue Inlet on the eastern portion of Bear Island." Conservation Unit NC-10 contains 356 acres of habitat that includes the primary constituent elements for the piping plover in the wintering range of the species.

The North Carolina Natural Heritage Program states that an historic osprey nesting area was present more than 20 years ago in the areas of Onslow County as well as, a marsh bird nesting area more than 20 years ago in Carteret County. The Natural Heritage Program designates the areas where nesting was documented including the Bogue Inlet area, as historic natural communities.

The U.S. Congress has also designated a portion of Bogue Inlet (Figure 17.2) as an Otherwise Protected Area (NC-06P) under the Coastal Barrier Resources Act (CBRA). CBRA was enacted in October 18, 1982, (Public Law 97-348, 96 Stat. 1653; 16 U.S.C. 3501 et seq.) designating certain undeveloped coastal barrier islands, for inclusion in the Coastal Barrier Resources System (USFWS, 2003).

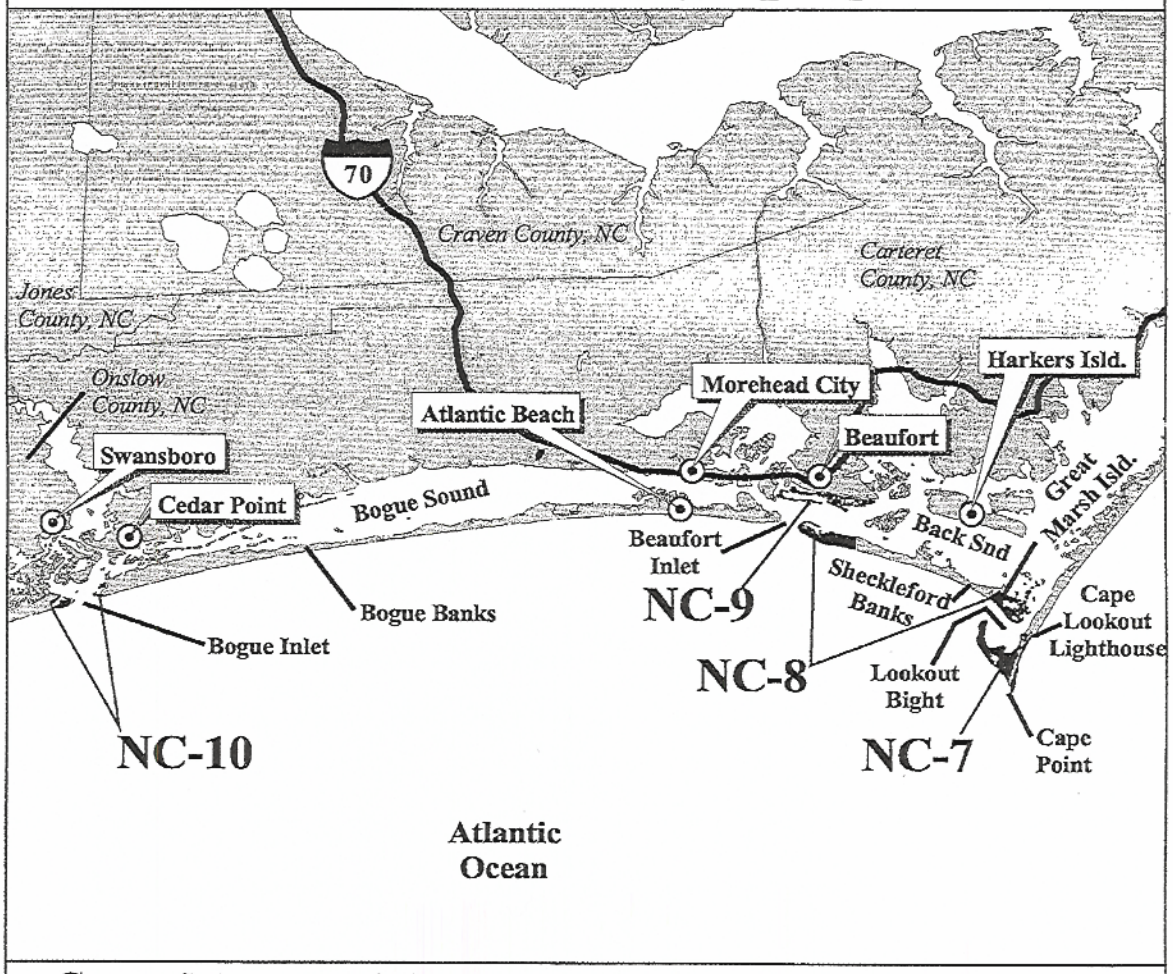
17.6.2 Effect Determination

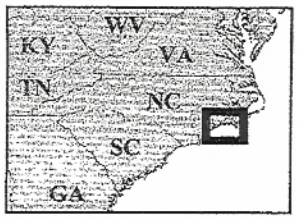
Primary constituent elements likely to be directly or indirectly affected by the project through dredging, sand displacement and/or nourishment efforts include: the intertidal shoals in Bogue Inlet (dredging); the ocean shoreline of Bear Island (sand displacement) and Emerald Isle (sand displacement/nourishment); and the west end of Emerald Isle (sand placement and spit displacement). Dredging the intertidal shoals of Bogue Inlet will likely affect the primary constituent elements utilized by wintering piping plovers. However, dredging operations within this sensitive habitat will be minimized by limiting work within the intertidal shoals to the greatest extent possible. Also, the use of a cutter suction dredge will avoid direct contact with the interior areas adjacent to the construction zone.

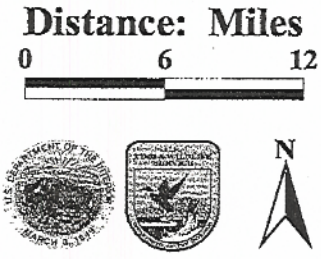
Additional mitigation and minimization measures being considered for implementation during project development include:

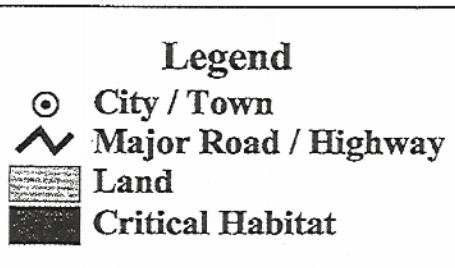
- Establishing access restrictions around piping plover nesting areas along west end of Emerald Isle during breeding season using approved barriers;
- Signage in the vicinity of Critical Habitat for Wintering Piping Plover to educate the public on the bird's behavior, identification and need to protect the habitat;
- Implementation of a habitat management plan that limits public access to nesting piping plover habitat especially during nesting season; and

General locations of the designated critical habitat for the Wintering Piping Plover.



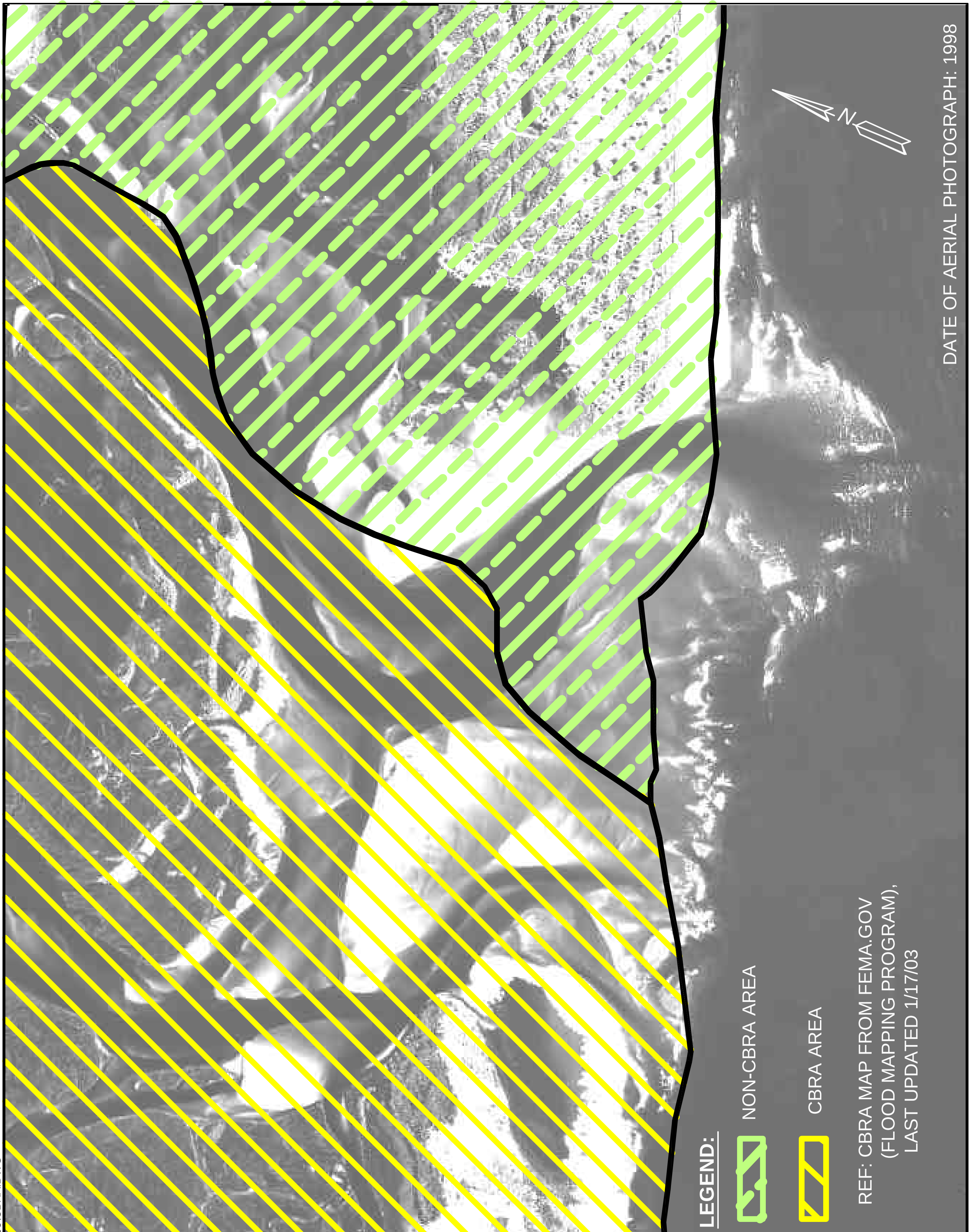






Use Constraints: This map is intended to be used as a guide to identify the general areas where Wintering Piping Plover critical habitat has been designated. Included within the designation of critical habitat are all land areas to the mean lower low water. Refer to the narrative unit descriptions as the precise legal definition of critical habitat.

North Carolina Units: 7, 8, 9 and 10



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COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BLVD.
BOCA RATON, FL 33431
PH. (561) 391-8102 FAX (561) 391-9116

TITLE:

CBRA DESIGNATION

DATE: 6/4/03	BY: JRC	COMM NO.: 4500.03	FIGURE NO. 17.2

- Use of a qualified biologist during construction activities to monitor the vicinity of piping plover, shorebirds, colonial waterbirds, and marine mammals to assure minimal disruptions; as; and/or
- Implementation of a conservation area for piping plover habitat.

17.7 ROSEATE TERN

17.7.1 Status and Natural History of Species in Project Area

Roseate terns (*Sterna dougallii*) have been observed along the coast of Carteret County for more than 20 years. They have been found to breed primarily on small offshore islands, rocks, cays, and islets. Nesting generally occurs near vegetation or jagged rock formations, on open sandy beaches, close to the waterline on narrow ledges of emerging rocks, or among coral rubble (USFWS, 2003). This species has been found south of Cape Hatteras, particularly at Cape Point within the Cape Hatteras National Seashore, during the months of July and August.

17.7.2 Effect Determination

The roseate tern has not been documented in the vicinity of the project. Considering that the tern has been observed primarily during the summer months, the proposed winter construction schedule is not likely to adversely affect roseate terns.

17.8 SEABEACH AMARANTH

17.8.1 Status and Natural History of Species in Project Area

Seabeach amaranth (*Amaranthus pumilus*) is an annual herb that can be found on barrier island beaches, lower foredunes and overwash flats. Flowering begins when plants have reached the appropriate size, and can begin as early as June, but more typically commences in July. The flowering period usually ends in late fall and seed production begins in July or August, reaching its peak in September and continuing until the plant dies back in the winter (USFWS, 2003).

17.8.2 Effect Determination

Since the plant will be in its seed stage during construction activities (November 16, 2004 through March 31, 2005), adverse affects to this species are expected to be minimal. The proposed channel relocation will occur below the water line where seabeach amaranth does not grow. However, deposition of the material along the west end of Emerald Isle may adversely affect this species. As a protective measure for seabeach amaranth and other dune floral species, sand placement along the Emerald Isle shoreline will be restricted to those areas where no vegetation is present.

This plant has been identified as a prolific seed producer, capable of producing thousands of seeds during its growing season (David Nash, personal communication, 2002). Other North Carolina beach nourishment project monitoring has shown that newly deposited clean sand allows for the recruitment of seabeach amarauth from adjacent habitats to the nourished area.

Sand is expected to accrete along the eastern end of Bear Island and western ocean shoreline of Emerald Isle as a result of the development of the new channel. A majority of this accretion will occur naturally, especially along Bear Island, and deposition is expected below the dune elevation, expanding the available plant habitat. The North Carolina Department of Parks and Recreation has been conducting seabeach amaranth surveys along the east end of Bear Island since 1991. The 2002 survey included a complete survey of Bear Island from Bogue Inlet to Bear Inlet. This survey identified fifty plants located on the eastern end of Bear Island. The project is not expected to adversely affect seabeach amaranth along the ocean shoreline of Bear Island or Emerald Isle since habitat needs are above the high tide line and extend to the dune toe.

The COE has instituted a long-term seabeach amaranth monitoring program at every beach in North Carolina that routinely receives dredged material from federally funded projects. Cooperation with the COE regarding specific protection measures for seabeach amaranth may be required during construction activities.

18. EFFORTS TO ELIMINATE POTENTIAL IMPACTS TO LISTED SPECIES: The proposed project will occur during the winter months, November 16, 2004 through March 31, 2005, which will minimize potential impacts to listed species because the work will occur outside or prior to sea turtle nesting season; the critical life stages of bird and fish species; the migratory season of marine mammals; the spring larval recruitment period for macroinvertebrates and infaunal species; and will avoid the vegetated cycle of the seabeach amaranth. Work during this time period will also avoid any impacts to manatees and other migratory marine mammals that may be found during the months of November to February.

Several mitigation measures may be implemented to minimize and avoid adverse impacts to both Federal and State protected species and their habitat during and after project construction. These measures or expected benefits from project implementation include:

1. Establishing access restrictions around piping plover nesting areas along the west end of Emerald Isle during breeding season using the approved barriers;
2. Signage in the vicinity of Critical Habitat for wintering piping plover to educate the public on the bird's behavior, identification and need to protect the habitat;
3. Implementation of a habitat management plan that limits public access and usage to nesting piping plover habitat especially during nesting season;
4. Creation a sand dike along the existing main ebb channel to assist in the closure and infilling of the abandoned waterway. This mitigation measure will immediately replace a portion of the habitat lost during channel relocation and quicken the reestablishment of sufficient intertidal habitat for infaunal recruitment and beach and dune communities for turtles and bird species;
5. Installation of the sand dike will assist in the rapid growth and development of a sand spit along the western shoulder of Bogue Banks and shoaling along the ocean side of the existing channel, providing habitat for listed species and their critical habitats;
6. Shoreline accretion along 7500 feet of oceanfront shoreline of Bear Island resulting in the preservation of beach and dune systems for seabeach amaranth and sea turtle nesting;

7. Anticipated development of the complex spit that currently extends into the eastern channel. This area may be considered as conservation land and mitigation for potential temporary shorebird and salt marsh habitat losses resulting from project construction;
8. Sand placement and dredge operations outside of primary invertebrate production and recruitment periods (spring and fall) thereby limiting impacts to amphipods, polychaetes, crabs and clams. Natural recruitment and repopulation of disturbed areas are expected to result in minimal impacts from the sand relocation efforts;
9. Use of a qualified biologist during construction activities to monitor the vicinity of piping plover, shorebirds, colonial waterbirds, and marine mammals to assure minimal disruption; and
10. An ocean certified cutter suction hydraulic dredge will be used to minimize the potential for impacts to sea turtles and marine mammals;
11. Biological monitoring of infaunal species, birds and saltmarsh will be conducted for one-year prior to construction and for three years after construction completion. This extensive monitoring plan will be used to evaluate project affects and develop mitigation requirements if necessary;
12. Digital aerial photography, surveying and habitat ground-truthing conducted during the summer of 2002 will provide updated habitat and physical information of the project study area.
13. Approximately 80% or more of the well-sorted sand material removed from the dredged channel will be used for beach renourishment along Emerald Isle. The proposed nourishment material is similar to the existing beach material in both color and grain size and is considered to be well suited for beach nourishment. This material will greatly contribute to the re-establishment of sea turtle nesting habitat along Phase 3 of Bogue Banks;
14. Sand compaction may be monitored within the Phase 3 project area. If required, the Phase 3 project area will be tilled prior to April 1st for up to three years following project construction to address compaction issues;
15. Visual surveys of escarpments along the project area will be made immediately after completion of sediment placement; and
16. If work occurs during turtle nesting season, beach monitoring and nest relocation of at risk sea turtle nests will be performed. This program will be conducted in a consistent manner with USFWS and North Carolina Fish and Wildlife Commission regulations.

19. SUMMARY EFFECT DETERMINATION: This assessment has attempted to examined the potential impacts of the proposed project on federally listed plant and animal species likely to be found in the project area. Both direct and indirect affects from the proposed work have been considered in this analysis.

The minimization and mitigation measures presented in this assessment indicate that the proposed work may negatively effect the following species: loggerhead sea turtle, Kemp's Ridley sea turtle, green sea turtle, and the Critical Habitat for Wintering Piping Plover. However the proposed work is not expected to jeopardize the continued existence of any of these species.

20. CULTURAL RESOURCES INVESTIGATION AND MAGNETOMETER SURVEY:

The area was originally home to nomadic Native Americans of, the Algonquin Indian tribe, from 500 A.D. to about the Colonial times. Later, the area was occupied by whalers and fishermen who settled in the vicinity of Bogue Inlet.

Around 1730, the first permanent settlement was established on the site of a former Algonquin Indian Village at the mouth of the White Oak River. The settlement was named Swansborough after Samuel Swan, former Speaker of North Carolina's House of Commons. It became a thriving port with shipbuilding as its major industry. Around 1950, Henry K. Fort bought a largely unsettled area on Emerald Isle and attempted to establish a resort. When the resort failed, a ferry system transported motorists and pedestrians to the Bogue Inlet Pier. Bogue Inlet Pier became the first recreational site on at the island's west end. Bogue Inlet and the surrounding areas remained largely unsettled until the 1950's.

20.1. Shipwrecks

The Cape Lookout area, which includes ocean waters stretching from Drum Inlet around the Cape to Bogue Inlet, contains at least 184 historically documented shipwrecks. Throughout the 1700's, the area was known as pirate territory. The famous pirate Blackbeard, supposedly used the inlets along the North Carolina coast and the shallow waterways behind the barrier island as a safe haven. It is thought that Bear Island was used by Blackbeard while he terrorized traders. It has also been suggested that the shipwrecks off the coasts of North Carolina are largely due to Blackbeard and his pirates. In fact, it is believed that one shipwreck, directly off the coast from Beaufort Inlet, could be Blackbeard's pirate ship, *Queen Anne's Revenge*, which sunk around 1718.

During times of war, the Inlet has played various important roles. During the Revolutionary War, a number of Patriot Privateers operated through Bogue Inlet preying on English merchant ships. Bear Island played a role in the protection of the mainland during the Civil War as a station for Confederate soldiers that prevented Union landings. During World War II, the Coast Guard used Bear Island to secure the coast and monitor German U–boat activity.

During the 1920's, the depression brought the development of commercial industry to Bogue Inlet. The long maritime history of the area indicates the possibility that shipwrecks or other valuable submerged historic resources may exist in areas seaward of Bogue Inlet. The National Historic Preservation Act of 1966 and Archeological and Historic Act of 1979 establish criteria for identification, documentation and assessment of submerged cultural resources. Compliance with submerged cultural resource legislation is administered by the North Carolina Division of Archives and History and the U.S. Department of the Interior. These archives and governmental agencies do not mention the presence of any shipwrecks in or near Bogue Inlet.

20.2 Department of Cultural Resources (NCDCR)

The NCDCR will be contacted to review the project for recommendations and/or known historic sites in the project area. The NCDCR will be contacted immediately upon the discovery of a historic artifact, and work will cease in the area until cleared by the NC DCR.

20.3 Magnetometer Testing

In the fall of 2002 Tidewater Atlantic Research (TAR) of Washington, North Carolina conducted a cultural resources remote sensing survey using a magnetometer for the ebb shoal and ebb channel of Bogue Inlet. Due to the combination of high wind and sea conditions, TAR was unable to survey the shallow areas of the tidal shoal system. Completion of the survey of this area is scheduled for June 2003.

One magnetic anomaly was identified in the vicinity of the proposed channel dike. Further investigations of this area will include a side scan of the channel bottom to determine if the target is buried or exposed; and a contour of the target to identify its shape and size.

To date, no magnetic anomalies have been identified in the vicinity of the proposed channel location.

The submerged cultural resources desktop study of the historical background has been completed. A final report of findings will be submitted to the COE after remaining field investigations and analysis have been completed.

Coordination will be maintained with State and Federal Departments of Historical Resources.

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APPENDIX 1

BIOLOGICAL MONITORING PLANS

TOWN OF EMERALD ISLE, NORTH CAROLINA
BOGUE INLET CHANNEL RELOCATION PROJECT

MACROINVERTEBRATE/INFAUNAL
PRE- AND POST-CONSTRUCTION MONITORING PROGRAM

Prepared For:
Town of Emerald Isle, North Carolina

Submitted To:
U.S. Army Corps of Engineers
Wilmington, North Carolina

Prepared By:
Coastal Planning & Engineering of North Carolina, Inc.
Wilmington, North Carolina

December 2002
(Rev. May 2003)

TOWN OF EMERALD ISLE, NORTH CAROLINA
BOGUE INLET CHANNEL RELOCATION PROJECT

MACROINVERTEBRATE/INFAUNAL
PRE- AND POST-CONSTRUCTION MONITORING PROGRAM

1. PURPOSE AND GOALS: The following sampling and monitoring plan has been developed in support of an Environmental Impact Statement for the Bogue Inlet Channel Relocation Project. The monitoring and sampling plan is intended to address the need for baseline data collection and analysis of macroinvertebrate and infaunal species in the vicinity of the project area.

The monitoring and sampling plan will provide information on indigenous species in the proposed inlet channel on the intertidal shoal and along the intertidal habitat of the existing inlet. Infaunal sampling will also occur at the three permanent transect locations in the salt marshes. This plan is intended to support the concerns of the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, National Marine Fisheries Service, the North Carolina Department of Environment and Natural Resources, the North Carolina Division of Marine Fisheries, and the North Carolina Wildlife Resource Commission.

Sampling efforts are proposed to assess and document the potential effects of project activities on infaunal species in the intertidal areas of the inlet system and adjacent salt marsh environments. Sampling efforts will concentrate on the areas of potential direct and indirect impacts where biota and physical conditions are most likely to be affected by project activities.

2. MONITORING SCHEDULE: Monitoring of macroinvertebrate and infaunal species in the existing and proposed channels and salt marsh locations began April 2003 and will continue for one year prior to construction activities and for three years post-construction. Macroinvertebrate and infaunal sampling in the intertidal areas of the inlet and salt marsh system will be conducted on a seasonal basis during the months of April, July, October, and January. Infaunal sampling at the three salt marsh monitoring stations will assist in characterizing shoal versus marsh species.

Sampling will not occur during construction activities due to accessibility and safety issues, but will continue at each sampling station for two years post-construction.

The proposed project will be constructed between November 16th and March 31st to limit construction activities during the critical life stages of birds and fish, the turtle nesting and hatching season, the migratory passage of marine mammals, and the flowering stages of plants.

3. BIOLOGICAL MONITORING PARAMETERS:

3.1 MACROINVERTEBRATE/INFAUNAL SAMPLING

Six sampling stations are located along the existing channel (Stations 1-3) and adjacent to the new channel alignment (Stations 4-6). One sampling site (Station 7) is located in the intertidal habitat on the south side of Island No. 2. This sampling station will be used as a reference site for the infaunal samples. Three additional infaunal sampling stations are located in the salt marsh environment. Refer to Figure 1 for the infaunal monitoring stations located in the salt marshes, existing and proposed channels. Three replicate samples will be collected at all ten sampling stations. Replicate samples will be located close together (approximately one foot apart) without being located at the previous sampling site or where sediments appear to be disturbed. If appropriate sampling habitat (water less than 1.0 foot deep) is not available within 200 feet of the proposed sampling site during the low tide event, then a Ponar grab sampler will be used to obtain the sample.

Sampling parameters will include coquina clams (*Donax variabilis*), mole crabs (*Emerita talpoida*), penaeid shrimp (*Penaeus* sp.), and amphipod and polychaete indicator species.

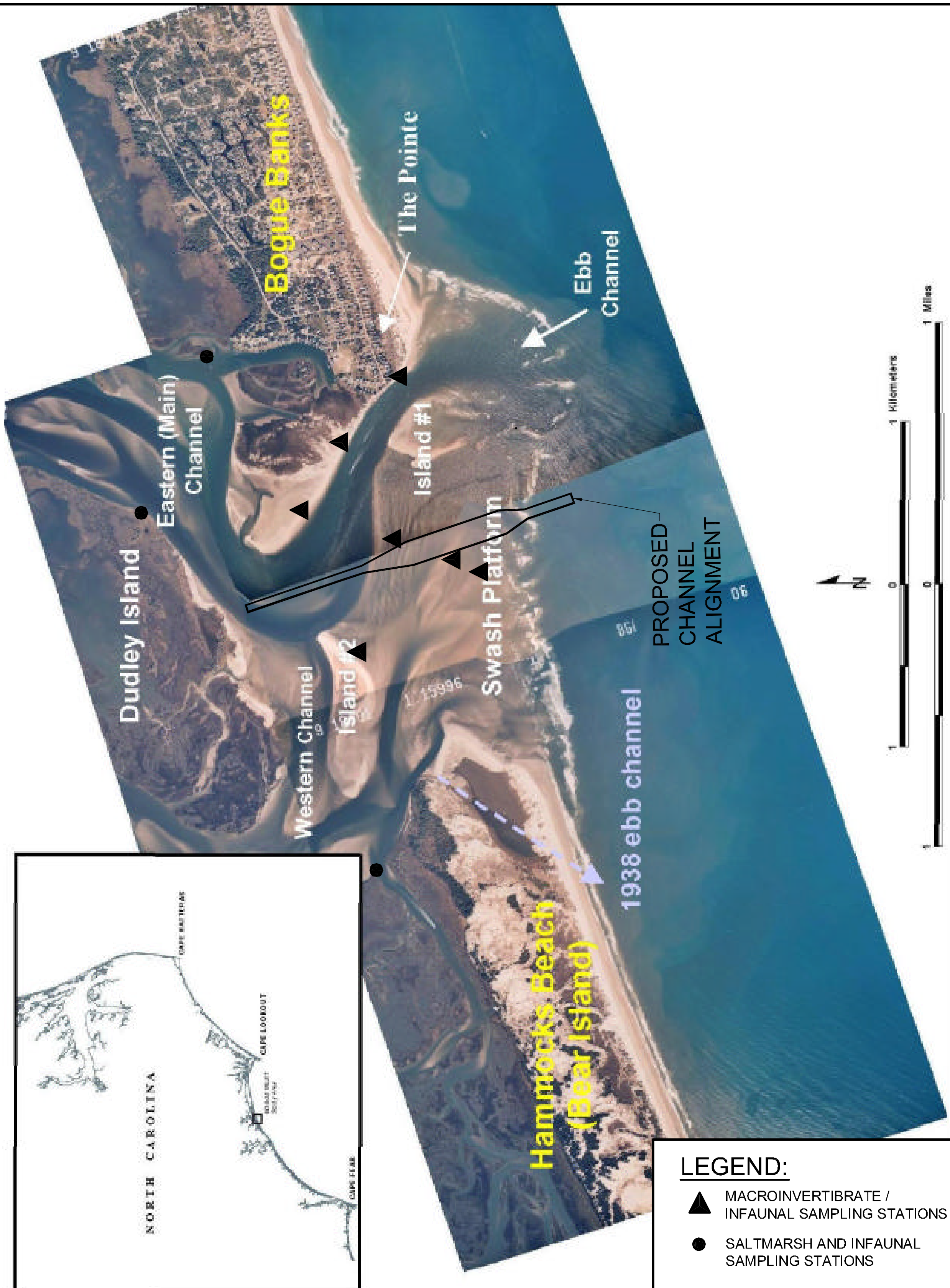
3.1.1 Existing and Proposed Channel Monitoring Stations

Infaunal sampling will occur at three locations along the existing channel and proposed new channel alignment to provide a good representation of the macroinvertebrate and infaunal species common to the project area. Quantitative sampling of the macroinvertebrates and infaunal species along the existing and proposed channels will occur in the intertidal environments between mean high water and mean low water (approximate elevations between 2.29 and –1.59 National Geodetic Vertical Datum) at each sampling station.

All macroinvertebrate and infauna samples collected along the existing inlet, proposed inlet, and reference site will be collected approximately six inches above mean low water to ensure that all samples are collected from the same intertidal microhabitat. This will be accomplished through the use of predicted and observed tides, field measurements, survey techniques, copious note taking and/or a handheld GPS device (especially along the existing inlet) to ensure that the samples are collected at the same location and depth. All samples will be collected at or about peak low tide to ensure that the mean low water stage is more easily observed.

The three sampling stations along the existing channel will be located along the east side of the channel. The station locations have been chosen to reflect a representative sample of infaunal and macroinvertebrate species on the seaward side, bayside and center of the existing channel.

Quantitative sampling adjacent to the proposed inlet will include three sampling stations. Sampling stations will be located from the inner to the outer intertidal shoal area on either side of the proposed inlet. Refer to Figure 2 for the proposed sampling stations along the existing and proposed channels.



LEGEND:

▲ MACROINVERTIBRATE / INFAUNAL SAMPLING STATIONS

● SALTMARSH AND INFAUNAL SAMPLING STATIONS

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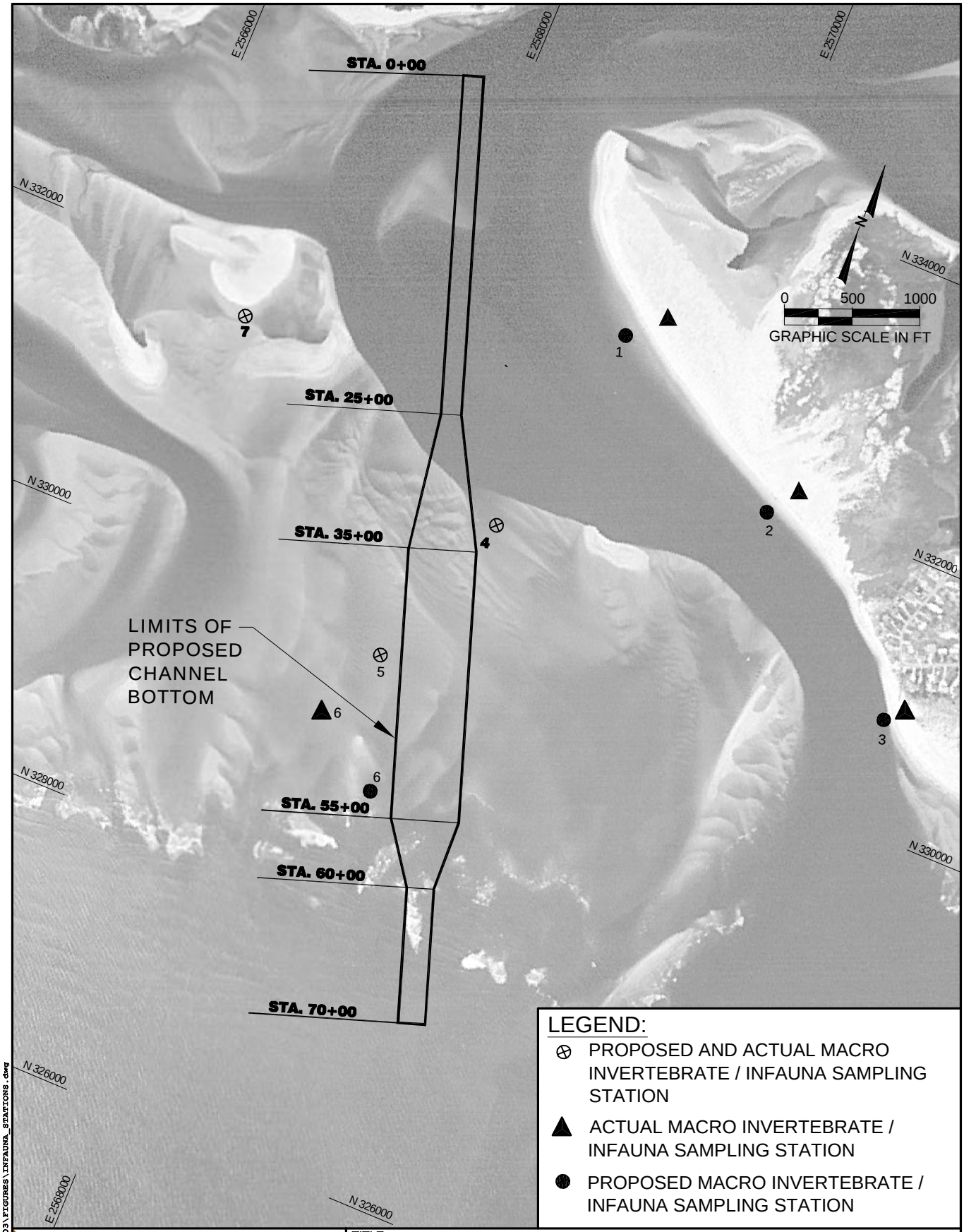
TITLE :

LOCATION OF SALTMARSH & INFAUNAL SAMPLING STATIONS

DATE: 4/28/03	BY: TW	COMM. NO.: 4500.03	FIGURE NO. 1



LEGEND:

- ⊛ PROPOSED AND ACTUAL MACRO INVERTEBRATE / INFAUNA SAMPLING STATION
- ▲ ACTUAL MACRO INVERTEBRATE / INFAUNA SAMPLING STATION
- ● PROPOSED MACRO INVERTEBRATE / INFAUNA SAMPLING STATION

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TITLE :

LOCATIONS OF INFAUNAL SAMPLING STATIONS IN EXISTING AND PROPOSED CHANNELS

DATE: 4/28/03	BY: TW	COMM. NO.: 4500.03	FIGURE NO. 2

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Sampling adjacent to the east and west sides of the proposed channel will provide evidence of any changes to the shoal habitat as a result of the dredging operations.

The reference site (Station 7) was chosen to reflect macroinvertebrate and infaunal species not directly impacted by the project.

3.1.2 Salt Marsh Monitoring Stations

Three infaunal sampling stations will be located at the selected salt marsh monitoring transects to identify infaunal species in the substrate of the salt marshes. One infaunal sample will be collected from each of the three transect locations, 5 feet from the salt marsh edge.

4. SAMPLING METHODOLOGY: A handheld PVC coring device (10 cm in diameter) will be used to collect samples at the selected sampling stations. The sampler will focus his/her attention on the proper use and handling of the device to ensure that reliable quantitative data is obtained. The handheld PVC coring device will penetrate 15 cm below the surface and carefully extracted to collect the sample. If deemed necessary, a sealing device will be used to retain the sample within the corer until it can be transferred to a container.

Following coring, the samples will be sieved through a 0.5 mm mesh box sieve for separating the mole crabs and coquina clams in the field. All samples will be retained in the sieve box and prepared for laboratory analysis. The samples will be fixed in a 10% buffered formalin solution mixed with Rose Bengal protein dye, sealed, labeled and transported to the laboratory for analysis. The sample will be fixed in the solution for at least 48 to 72 hours before sorting amphipods and polychaetes. Species will be identified to the lowest possible taxonomic level. After analysis, the samples will be transferred to a 50% isopropynol preservative for long-term storage.

5. DATA ANALYSIS AND REPORT PREPARATION: Infaunal data for each station will be reported as the number of individuals from each taxon, the number of species and the total number of organisms per square meter. Brief descriptions of the types of diversity indices to be used during this study are provided below.

A. Shannon-Weaver (Shannon) Index of Diversity: The base 2, base 10 or natural log statistic will be used in defining the diversity of species. This index is based on the "information" theory, where diversity is equated to the amount of uncertainty that exists on the identity of an individual collected at random from a community. The more species and the more evenly the presentation of individuals, the greater the uncertainty and the greater the diversity (Milligan, 1990). The higher the Shannon-Weaver Diversity Index, the higher the species of diversity and the higher the equitability.

B. Simpson Diversity Index: This index emphasizes the degree of dominance by one or a few species and provides the probability that two individuals

drawn at random from the same community are the same species (Levington, 1982). Consequently, the higher the Simpson Diversity Index, the higher the degree of dominance by one or a few species, and the lower the species diversity and equitability.

C. Pielou Index of Equitability: Equitability is considered a component of diversity in that it provides an idea about the evenness of species distribution at a site. Usually, a positive correlation exists between diversity and equitability (i.e., high equitability would indicate high diversity) (Milligan, 1990).

D. Margalef's Index: Margalef's Index assumes a relationship between the number of individuals and the number of species in a sample. This index logarithmically scales the value of the number of species, and provides a comparison between stations with different ratios of number of species and individuals (Milligan, 1990).

Data analysis and observations obtained from each station will also include the following information: sampling device used; size and depth of the sample collected; and any other identifiable tubes, mound structures, fecal coils. Pre-project baseline data will be used in the evaluation of population regeneration following the dredge and fill operations at both the existing and proposed channels.

Annual reports documenting the findings will be prepared simultaneously with the saltmarsh monitoring report. Reports will be submitted to the USACE on February 30th of any year.

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TOWN OF EMERALD ISLE, NORTH CAROLINA
BOGUE INLET CHANNEL RELOCATION PROJECT

PIPING PLOVERS, SHOREBIRDS, AND COLONIAL WATERBIRDS
BIRD MONITORING PROGRAM

Prepared For:
Town of Emerald Isle, North Carolina

Submitted To:
U.S. Army Corps of Engineers
Wilmington, North Carolina

Prepared By:
Coastal Planning & Engineering of North Carolina, Inc.
Wilmington, North Carolina

December 2002
(Revised May 2003)

TOWN OF EMERALD ISLE, NORTH CAROLINA
BOGUE INLET CHANNEL RELOCATION PROJECT

PIPING PLOVERS, SHOREBIRDS, AND COLONIAL WATERBIRDS
BIRD MONITORING PROGRAM

1. PURPOSE AND GOALS: The following monitoring plan has been developed in support of an Environmental Impact Statement for the Bogue Inlet Channel Relocation Project. This monitoring plan is intended to address the need for observational data of piping plovers (*Charadrius melodus*), other shorebirds, and colonial waterbirds collected prior to, during and after construction.

The monitoring plan will provide information on indigenous and migratory bird species found nesting, roosting, foraging, and wintering in the vicinity of the project area. Survey areas will include the proposed channel location on the mid-tidal shoal and along the tidal habitats of the existing inlet. This plan is in response to the concerns expressed by the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service, National Marine Fisheries Service, North Carolina Department of Environment and Natural Resources, North Carolina Division of Marine Fisheries, and the North Carolina Wildlife Resource Commission (NCWRC).

2. MONITORING SCHEDULE: Monitoring of bird species began in April 2003 and will continue for one year prior to construction, during the construction period, and for three years post-construction. Prior to construction, monitoring of bird species will be conducted on a monthly basis until the start of the piping plover spring migratory season in March. Monitoring will be conducted approximately every 10 days during the spring migration (March 1st to April 30th); approximately every 15 days during the breeding season (May 1st to July 13th); and approximately every 10 days during the fall migration (July 14th to November 30th). Monitoring will return to the monthly schedule during the months of December thru February.

Upon commencement of construction activities, a weekly bird monitoring schedule will begin. At the end of construction, monitoring of bird species will return to the pre-construction schedule and continue for two years. (i.e., monthly monitoring from December through February; semi-monthly monitoring from April through November).

The proposed project will be constructed between November 16th and March 31st to limit construction activities during the critical life stages of birds and fish, the turtle nesting and hatching season, the migratory passage of marine mammals, and the flowering stages of plants.

3. BIOLOGICAL MONITORING PARAMETERS:

3.1 PIPING PLOVERS, SHOREBIRDS, AND COLONIAL WATERBIRDS MONITORING

Bird monitoring will occur along four transect areas: 1) the south side of Dudley Island, 2) the western extent of Emerald Isle along the existing channel, 3) along Island No. 2 and the mid-inlet shoal and 4) for 500 meters along the ocean shoreline of Bear Island. The bird monitoring program will focus on State and Federally listed species including the piping plover and gull-billed tern, but will include the activities of all shorebirds and colonial waterbirds observed along the transect locations.

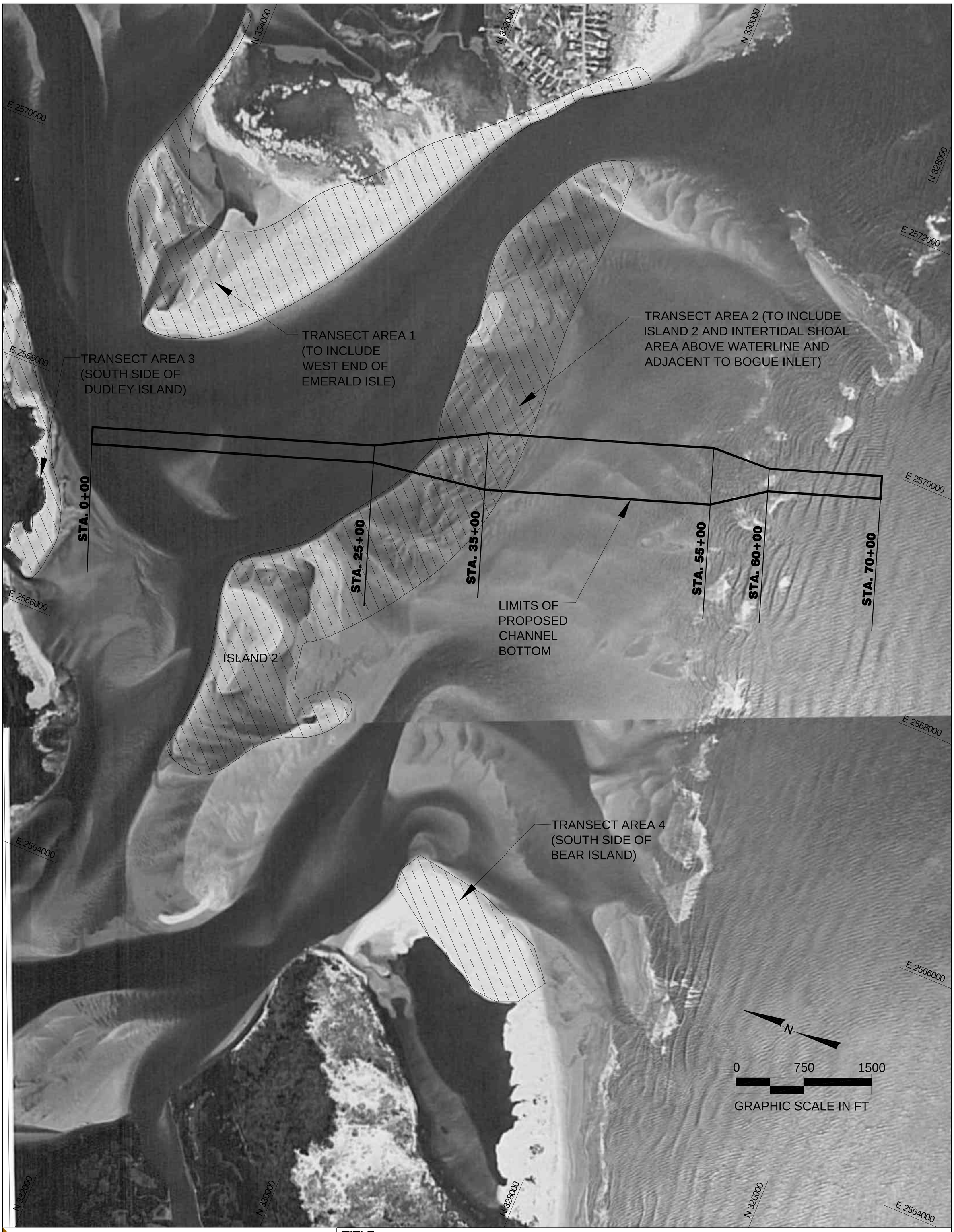
3.1.1 Transect Locations

Four transect areas have been chosen to observe bird activities in the vicinity of the proposed project. Transect Area No. 1 will begin along the northern edge of the west end of Bogue Banks, following the shoreline south to a location near The Pointe Subdivision. Transect No. 2 will encompass Island No. 2 and a portion of the eastern perimeter of the mid-inlet shoal. Transect Area No. 3 will encompass the potential project impact area along the beach of the south side of Dudley Island. Transect No. 4 will begin at the eastern extent of Bear Island proceeding west for 500 meters along the ocean shoreline of Bear Island. Monitoring areas will include accreting areas at inlets; bayside, sand and mud flats; and recently disturbed areas such as washovers. Figure 1 provides the location of the bird monitoring transect locations.

3.1.2 Observations

Bird monitoring observations will include the use of a spotting scope to identify nesting, roosting, and foraging, as well as territory establishment, courtship, and copulation. In addition to nesting pair counts and productivity data, monitoring of breeding sites will include other information important to evaluate species use and dependence. Data collection may also include:

- Dates when monitoring begins and ends;
- Detailed weather and tide data (i.e., approximate wind speed, direction and cloud coverage);
- Nesting chronology (dates when birds are first observed in the study area, nest establishment dates, dates when unfledged chicks are present on site);
- Locations of nests and brood foraging territories;
- Known and suspected causes of nest and chick loss;
- Indices of predator abundance (e.g., tracks, sitings);
- Locations of commonly used foraging areas during each stage of the breeding cycle;
- Use by post breeding or migrating waterbirds; and
- Identify band combinations on piping plovers, if possible.



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TITLE :

APPROXIMATE TRANSECT LOCATIONS OF PIPING PLOVER, SHOREBIRD AND COLONIAL WATERBIRD

DATE: 11/4/02	BY: EAH	COMM. NO.: 4500.02	FIGURE NO. 1

REV. 11/8/02
REV. 3/17/03

An effort will be made to survey all transect areas during the same low tide event to account for all birds in the area. Observations along Transect Areas 1 and 3 may be conducted during either low or high tide events, however observations along Transect Area Nos. 2 and 4 should be collected during low tide events to account for habitat usage along the mid-inlet shoal.

Due to accessibility and safety issues, bird monitoring along the mid-inlet shoal of Transect Area No. 2 will be conducted from a boat with the use of binoculars. Bird monitoring surveys will not be conducted during inclement weather (i.e., heavy rain) or when winds speeds are excessive.

Based on previous observations made by the NCWRC, they suggest that the north side of Transect Area No. 1 and Island No. 2 are focused on during bird monitoring events, since these areas have historically been frequented by piping plovers and other shorebirds.

4. REPORT PREPARATION: A quarterly report of the observations made along Transect Nos. 1-4 will be prepared and submitted to the USACE. An annual report summarizing the previous year's data will be prepared and submitted on May 30th of every year (through April 1st of the reporting year).

The NCWRC has anecdotal bird data of the Bogue Inlet area from 1985. Data obtained by the NCWRC from 1997 to the time of report preparation will be used for historic comparisons of species presence/absence and habitat use.

O:word/northcarolina/emeraldisle4500.00_03/environmental/biomonitoring/birdmonitoring/birdmonitoring.05.03.doc

TOWN OF EMERALD ISLE, NORTH CAROLINA
BOGUE INLET CHANNEL RELOCATION PROJECT

SALTMARSH MONITORING PROGRAM

Prepared For:
Town of Emerald Isle, North Carolina

Submitted To:
U.S. Army Corps of Engineers
Wilmington, North Carolina

Prepared By:
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Wilmington, North Carolina

December 2002
(Revised May 2003)

TOWN OF EMERALD ISLE
BOGUE INLET CHANNEL RELOCATION PROJECT

SALTMARSH MONITORING PLAN

1. PURPOSE AND GOALS: The following sampling and monitoring plan has been developed in support of an Environmental Impact Statement for the Bogue Inlet Channel Relocation Project. The monitoring plan is intended to address the need for data collection and analysis of the adjacent saltmarsh communities in the vicinity of the project area.

The monitoring plan will provide information on coastal marsh habitats that may be directly or indirectly affected by the channel relocation efforts. This plan is intended to support the concerns of the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service, National Marine Fisheries Service, the North Carolina Department of Environment and Natural Resources, the North Carolina Division of Marine Fisheries, and the North Carolina Wildlife Resource Commission.

Monitoring efforts are proposed to assess and document the potential effects of perturbations, such as sedimentation on adjacent saltmarshes. Sampling efforts will concentrate on representative areas of potential impact where biota and physical conditions may be affected by project activities and related effects.

2. MONITORING SCHEDULE: A total of four monitoring events will be conducted to determine if impacts are directly or indirectly attributable to project activities. The effects of perturbation on vegetative conditions will be most pronounced during active growth and development periods. Therefore, observations of these effects will be better identified at the end of the growing season (September/October). Pre-construction monitoring to collect baseline conditions will be conducted at the end of the growing season in either September or October 2003. Annual saltmarsh monitoring will continue for three-years post-construction.

The proposed project will be constructed between November 16th and March 31st to limit construction activities during the critical life stages of birds and fish, the turtle nesting and hatching season, the migratory passage of marine mammals, and the flowering stages of plants.

3. BIOLOGICAL MONITORING PARAMETERS:

3.1 SALTMARSH AND ECOLOGICAL MONITORING

Monitoring of the selected parameters identified below, along with the infaunal characterization will document and assess the potential effects of project activities on primary productivity in the saltmarsh habitat.

3.1.1 Monitoring Stations

Saltmarsh monitoring transects will be located at the following locations: 1) north of Bogue Inlet on the east side of the main channel, 2) on the east side of Dudley Island, and 3) north of Bear Island. Refer to Figure 1 for the saltmarsh monitoring stations.

3.1.2 Monitoring Parameters

The following monitoring parameters are based on the potential for indirect impacts to the adjacent salt marsh communities from the channel relocation efforts. Monitoring stations will include control stations of similar vegetation and tidal habitat. The monitoring parameters include:

- *Spartina* sp. stem density,
- Mature (>30 cm in height) *Spartina* sp. stem height,
- Percent sand, silt, and clay of surface substrate,
- Percent organic content of surface substrate,
- Sedimentation rate,
- Wildlife utilization, and
- Channel marsh edge erosion.

3.1.3 Methodology

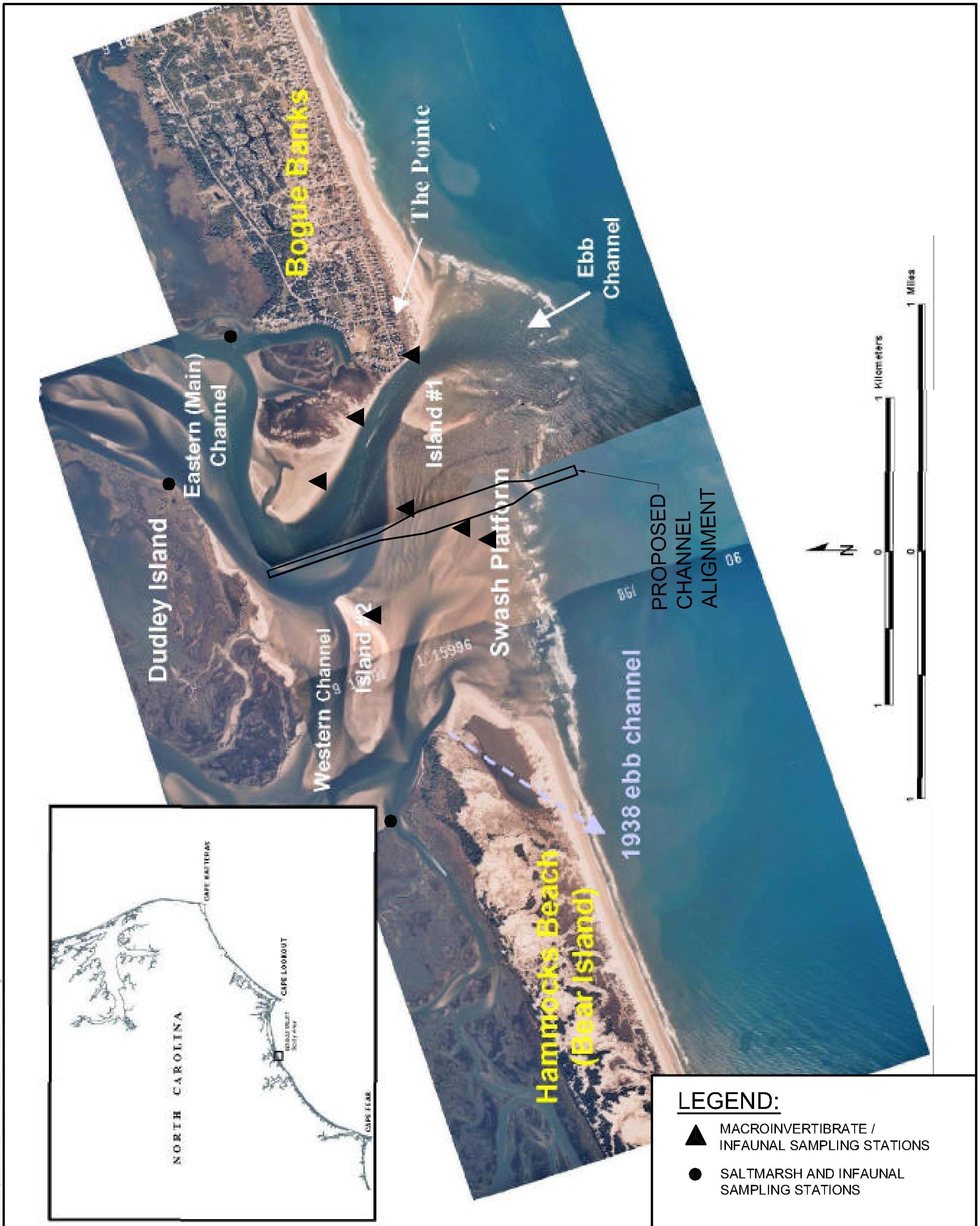
Three permanent 300 foot monitoring transects will be located in the saltmarsh areas in the vicinity of the project. Five one-meter square quadrats for each transect (located 5, 50, 100, 150, and 300 feet away from the marsh edge) will be sampled for stem density and height of *Spartina*. The transect located on the north side of Bear Island will serve as the relative control site for the other transects. This transect is not expected to exhibit project-related impacts.

Sediments will be characterized based on percent sand/silt/clay and percent organic content. Samples will be collected from the 5, 50, 100, 150 and 300-foot locations along each transect. In addition, graduated PVC piping will be installed prior to project construction to evaluate sediment deposition and/or erosion over time for each plot. The PVC will be exposed 3 to 4 feet above the existing sediment line to account for high sediment accretion rates.

Direct visual observations and indirect evidence will be used to document the presence of epibenthic macroinvertebrates and wildlife along the transect corridors. Each transect corridor will extend 150 feet from the edge of the marsh, roughly perpendicular to the channel, and will be three feet wide. Separate control transect corridors (150 feet by 3 feet) will be established parallel to the channel and intersect the 150-foot quadrat locations.

3.1.3 Organic Content Samples

One substrate sample per quadrat location will be collected to determine the organic content of the sediments. Samples will be collected to a depth of 15cm



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TITLE :

LOCATION OF SALTMARSH & INFAUNAL SAMPLING STATIONS

DATE: 4/28/03	BY: TW	COMM. NO.: 4500.03	FIGURE NO. 1

(10 cm in diameter) and placed in standard soil sample bags. Samples will be shipped to a certified agricultural testing laboratory for analysis of organic content, as well as percent sand/silt/clay.

4. **REPORT PREPARATION:** Monitoring reports documenting saltmarsh conditions will be prepared simultaneously with the infaunal monitoring report. The annual monitoring reports will be submitted to the USACE on January 1st of each year.

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APPENDIX 2

PRECAUTIONARY GUIDELINES FOR GENERAL CONSTRUCTION IN AREAS WHICH MAY BE USED BY THE WEST INDIAN MANATEE IN NORTH CAROLINA

Precautionary Guidelines for General Construction in Areas Which May Be Used by the West Indian Manatee in North Carolina

1. The applicant will inform all personnel associated with the project that manatees may be present in the project area, primarily during the months June through October, and the need to avoid any harm to these endangered mammals. The applicant will ensure that all construction personnel know the general appearance of the species and their habit of moving about completely or partially submerged in shallow water. All construction personnel will be informed that they are responsible for observing water-related activities for the presence of manatees.

2. The applicant will advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Endangered Species Act of 1973, as amended, and the Marine Mammal Protection Act of 1972, as amended.

3. If a manatee is seen within 300 ft of the active daily construction/dredging operation or vessel movement, all appropriate precautions must be implemented to ensure protection of the manatee. The precautions must include the operation of all moving equipment no closer than 50 ft of a manatee. Operation of any equipment closer than 50 ft to a manatee must necessitate immediate shutdown of the equipment. Activities will not resume until the manatee has departed the project area on its own volition. Manatees should not be herded away or harassed into leaving.

4. Any collision with and/or injury to a manatee will be reported immediately. The report must be made to the U.S. Fish and Wildlife Service and the North Carolina Wildlife Resources Commission immediately, and dredging should be postponed until cause of injury or mortality can be determined and a revised dredging and or monitoring plan is produced and approved by the Service.

5. A sign must be posted in all vessels associated with the project where it is clearly visible to the vessel operator. The sign should state:

> CAUTION: The endangered manatee may occur in these waters during the warmer months, primarily from June through October. Idle speed is required if operating this vessel in shallow water during these months. All equipment must be shut down if a manatee comes with 50 ft of operating equipment. A collision with and/or injury to a manatee will be reported immediately to the U.S. Fish and Wildlife Service and the North Carolina Wildlife Resources Commission.

6. The applicant/contractor will maintain a log detailing sightings, collisions, or injuries to manatees during project construction. After construction, the applicant/contractor will prepare a report which summarizes all information on manatees during construction. This report will be submitted to the U.S. Fish and Wildlife Service and the North Carolina Wildlife Resources Commission.

7. All vessels associated with the construction project will operate at "no wake/idle" speeds at all times while in water where the draft of the vessel provides less than 4 ft clearance from the bottom. All vessels will follow routes of deep water whenever possible.

8. If siltation barriers must be placed in shallow water, these barriers will be: (a) made of material in which manatees cannot become entangled; (b) secured in a manner that they cannot break free and entangle manatees; and, (c) regularly monitored to ensure that manatees have not become entangled. Barriers will be placed in a manner to allow manatees entry to or exit from essential habitat.